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FORMERLY UTILIZED MED/AEC SITES REMEDIAL ACTION PROGRAM

RADIOLOGICAL SURVEY OF THE ALBANY METALLURGICAL RESEARCH CENTER UNITED STATES BUREAU OF MINES ALBANY, OREGON

OCCUPATIONAL HEALTH AND SAFETY DIVISION
Health Physics Section
ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

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RADIOLOGICAL SURVEY OF THE ALBANY METALLURGICAL RESEARCH CENTER UNITED STATES BUREAU OF MINES ALBANY, OREGON

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PREFACE AND EXECUTIVE SUMMARY

This is one in a series of reports resulting from a program initiated in 1974 by the Atomic Energy Commission (AEC) to determine the condition of sites formerly utilized by the Manhattan Engineer District (MED) and the AEC for work involving the handling of radioactive materials. Since the early 1940s, the control of over 100 sites that were no longer required for nuclear programs has been returned to private industry or the public for unrestricted use. A search of MED and AEC records indicated that for some of these sites, documentation was insufficient to determine whether the decontamination work done at the time nuclear activities ceased is adequate by current guidelines. The Albany Metallurgical Research Center operated by the U.S. Bureau of Mines in Albany, Oregon, is one such site. The results of surveys initiated in 1978 to determine the current radiological conditions of major portions of the Albany facility are presented in this report. Survey results of two peripheral areas-- known as the BioMass Facility and the Back Forty Area--are contained in a companion report (ANL-OHS/HP-83-101).

During the periods 1954 to 1956 and 1960 to 1971, the Albany Metallurgical Research Center (AMRC) was engaged in metallurgical operations that included melting, machining, welding, and alloying of thorium. In addition, research on alloys of uranium and thorium started in 1955 and continued until suspended in 1978.

Records indicated that at the time the original AEC contract was terminated, buildings and surrounding areas were decontaminated to the general guidelines provided by the AEC. Those guidelines were not as specific as current guidelines, and detailed records of the final decontamination were not documented. Because of that, radiological assessment of this site was initiated in June 1978. During June and July 1978, a radiological survey of the grounds and the buildings was completed. Certain buildings were designated as areas where no survey was necessary; however, it was decided by the ANL survey team to at least perform floor surveys in those buildings (2, 6 through 16, 18 through 21, and 32 through 34). Complete surveys that included floor and wall surveys, smears, and air

samples were performed in Buildings 1, 3, 5, 17, 22 through 28, and 31. Radioactive material are still handled in Buildings 4 and 30, so except for one room, those buildings were not surveyed. (Room 8 in Building 30 was surveyed since it was used in conjunction with past activities in Building 31 involving radioactive material.) The grounds, walkways, and docks on the AMRC site were also surveyed.

During the survey in Building 31, floor trenches were found to be radioactively contaminated. Because of that finding, a sludge sample was taken from the sewer at the corner of Queen Avenue and Liberty Street adjacent to the AMRC. Elevated levels of uranium and thorium were found in the sample.

In August and September of 1979, 11 sewers, some upstream and some downstream from the AMRC, were surveyed. Instrument readings, smears, air samples, water samples, and sludge samples were taken in these sewers to determine if any contamination was present as a result of the operations of the AMRC. Water samples also were collected from the Albany waste treatment plant. In addition, instrument readings and soil samples were taken in fields at the Ohling Farm, where sludge from the waste treatment plant was used as fertilizer. In 1979, AMRC personnel indicated that contamination might be present in areas on the AMRC site other than those already surveyed. A septic system behind Buildings 12 and 17 was mentioned as one such area, so that feature was included in the survey.

Subsurface investigation of the AMRC site was initiated in September 1980; that investigation, as well as the radiological survey of the entire grounds, was completed during September 1982.

Significant levels of contamination, both loose and fixed, were found in 10 of the 33 buildings surveyed. In addition, about 60 contaminated areas, including 17 with loose contamination, were found outside the buildings. Surveys of the sanitary sewers, the Albany sewage treatment plant and the Ohling Farm showed no significant contamination. Significant levels of contamination were found in the septic system behind Buildings 12 and 17. Air samples taken throughout the site revealed no radon concentrations in excess of the limits proposed by the U.S. Surgeon General (10 CFR 712).

The site subsurface investigation consisted of collecting 22 environmental soil samples (4 in diameter by 12 in deep) and drilling 48 bore holes (10 ft deep). Five environmental samples also were taken on the Ohling farm. All soil samples and borings were analyzed for uranium using uranium fluorometry, and for radium and thorium using high resolution gamma spectrometric techniques. Some samples were further analyzed for specific thorium isotopes using alpha spectrometric techniques. Each bore hole also was logged with a 2 x 2 in NaI(Tℓ) detector prior to backfilling. The subsurface contamination (detected by these analyses) was primarily within the main site and seemed to be restricted to depths of 1 or 2 feet.

Although the levels of contamination at this site do not pose an immediate health hazard, it is our conclusion that in keeping with the regulatory concept of reducing radiation exposure to levels "as low as reasonably achievable," decontamination and cleanup of the facility would be appropriate in order to pursue the intent of the ALARA goals.

This survey was performed under the auspices of the Health Physics Section of the Occupational Health and Safety Division of Argonne National Laboratory, Argonne, Illinois. The following personnel participated: R. A. Wynveen, W. H. Smith, R. L. Mundis*, C. B. Mayes,** A. L. Justus, K. F. Flynn, J. G. Ello, C. A. Hunckler, J. D. Thereon, R. Rodriguez, D. W. Reilly, and P. C. Gray.***

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

RADIOLOGICAL SURVEY OF THE ALBANY METALLURGICAL RESEARCH CENTER UNITED STATES BUREAU OF MINES ALBANY, OREGON

INTRODUCTION

During the Manhattan Engineer District/Atomic Energy Commission (MED/AEC) era, some work involving radioactive materials was performed at the Albany Metallurgical Research Center of the United States Bureau of Mines in Albany, Oregon (see Fig. 1). During the periods 1954 to 1956 and 1960 to 1971, metallurgical operations involving melting, machining, welding, and alloying thorium were conducted at the site. Also, these operations included research on alloys of both uranium and thorium started in 1955 with some activities continuing until 1978 under Contract No. E(04-3)-906.

When the contract was suspended in 1978, records indicated that structures of concern were decontaminated in accordance with general guidelines prescribed at the time. Those guidelines, however, were not as specific as current guidelines. Likewise, details of certain of the final decontamination activities were not documented to the extent necessary, particularly for the case of those activities which occurred in the 1950s. As a consequence, U. S. Department of Energy (DOE) has undertaken a radiological characterization and assessment study to determine the radiological condition of this site. This study was initiated as part of a DOE program intended to ensure that residual radioactive material from past MED/AEC operations do not pose undue present or future radiological hazards.

The entire Albany Metallurgical Research Center (AMRC) site has undergone a comprehensive radiological survey. Survey results for two peripheral areas known as the BioMass Facility and the "Back Forty" are presented in a companion report (ANL-OHS/HP-83-101). This report deals with the survey for the remainder of the site. A site plan of the AMRC is shown in Figure 2.

SURVEY AND ANALYTICAL TECHNIQUES

General

This radiological survey, which was performed by the Argonne National Laboratory Radiological Survey Group for the U.S. Department of Energy, encompassed the Albany Metallurgical Research Center and some offsite features. Included were the following structures and areas: (1) all buildings on the site (Fig. 2), (2) the lawns, roadways, and docks on the site, (3) a septic system (drain tile field) behind Buildings 12 and 17 (which was reportedly used for dumping of radioactive materials) (Fig. 3), (4) some of the sanitary sewers close to the AMRC site (Fig. 4), (5) the Albany waste treatment plant (Fig 5), and (6) the Ohling Farm (Fig. 6).

The methods used in the survey on the AMRC site and in the nearby sewers included performing instrument surveys of radiation levels and analyzing smears and water, air, and soil samples (sludge samples in the cases of the sewers and septic system). In addition, water samples taken from the Albany waste treatment plant were analyzed. At the Ohling Farm (where sludge from the waste treatment plant had been used for fertilizer), instrument surveys were performed in fields and soil samples were collected for analysis.

Certain buildings were designated as areas where no survey was necessary. Nevertheless it was decided by ANL to at least perform floor surveys in Buildings 2, 6 through 16, 18 through 21, and 32 through 34. Complete surveys, including floor and wall instrument surveys and smears were performed in Buildings 1, 3, 5, 17, 22 through 28, and 31. If any contamination was found during the floor surveys of the former group of buildings, then a complete instrument and smear survey of floors and walls would be performed in those buildings where contamination was found. Because radioactive materials were still handled in Buildings 4 and 30, they were not surveyed (except Room 8 in Building 30, which was previously used in conjunction with activities in Building 31 involving the handling of radioactive materials.)

Within the buildings where complete surveys were conducted, all accessible floors and original walls (to a height of 7 ft) were surveyed. Representative selections of overhead structures, such as pipes, vents, and light fixtures, were also surveyed. In many areas, the floors and walls had been retiled or painted. Even though these were not the original surfaces, these areas were

surveyed since the survey instrument used could detect beta-gamma activity on the original structures underneath. Locations of areas surveyed are indicated in Table 1. [All measurements were originally taken using the English system. The Systems International (SI) units are to the nearest approximation. For example, 2 in. $\tilde{\sim}$ 5 cm].

In addition to the interior surveys, all lawns, roadways, and docks were surveyed with portable instruments. The surfaces of exterior ground areas were surveyed in their entirety (i.e., 100%), obviating the need for any gridding with the concomitant statistical evaluation of potential for error due to sampling uncertainties.

Instrumentation

Four types of portable survey instruments were used to conduct the direct radiological surveys. Gas-flow proportional detectors with window areas of 51 cm^2 and 325 cm^2 (using Eberline PAC-4G-3 electronics) were used to monitor for alpha and/or beta-gamma radiation. NaI crystal detectors, 2-in diameter by 2-mm thick (Eberline PG-2 with Eberline PRM-5-3 electronics), were used to monitor for low energy x-ray and gamma radiation. NaI crystal detectors, measuring 1-in diameter by 1-in thick (Eberline PRM-7 μR meter) and calibrated with a ^{226}Ra standard source, were used to measure the ambient external penetrating radiation field in units of μR/h. An end-window Geiger-Mueller (GM) detector (Eberline HP-190 with a 7 mg/cm^2 window and Eberline 530 electronics), calibrated with a ^{226}Ra standard source, was used to measure the contact exposure rate (mR/h) of contaminated areas. Integrated measurements of the ambient penetrating radiation field were taken with a pressurized ionization chamber (Reuter-Stokes RSS-111) calibrated with an NBS traceable gamma-ray source. These instruments and associated calibration procedures are detailed in Appendices 1 and 2.

When possible, a contaminant was identified by performing gamma spectral analysis on the contaminated item, on a sample of material taken from the contaminated item, or on a sample of material taken from a contaminated area. These analyses were performed with a sodium iodide or HPGe detector coupled to a multichannel analyzer. This instrumentation is also described in Appendix 1.

Smear Surveys

Dry smears were taken at representative locations throughout each building with 4.25-cm-diameter filter papers (Whatman #1). A standard smear sample is obtained by applying moderate pressure with the tips of the first two fingers to the back of the filter paper and wiping the surface over an area of approximately 900 cm^2. Smears were taken on original structures and components such as walls, floors, pipes, and vents. A smear of 100 cm^2 was taken from any area or object indicated by a portable survey instrument to have a higher than normal radiation level. A smear of 100 cm^2 was also taken if the surface was extremely dusty.

To expedite the counting of the numerous smear samples collected, two counting techniques were employed with two types of counters. A large-area, thin window, gas-flow proportional counter, sensitive to alpha and/or beta-gamma radiation, was used to make an initial count on groups of smears. For confirmatory counts on individual smears noted to be above the expected background level a Nuclear Measurement Corporation, Model PC-5 or 3A, internal gas-flow proportional counter (PC counter) with a thin aluminized Mylar window (referred to as Mylar spun top) was used.

Initial counts were made with the large-area counter on groups of ten smears at a time. Smears from any group indicating a reading above the instrument background were then counted individually in the PC counter. In addition, at least one smear of each group of ten was selected at random and counted in the PC counter. All smears of the areas or objects with elevated direct readings were counted individually in the PC counter. A more detailed description of the counters used and of the counting and calibration techniques used is presented in Appendix 1.

Air Samples

Air-particulate samples were collected using a commercial vacuum cleaner (ANL-modified) to pull air through filter media (Hollingsworth-Vose HV-70). A total volume of 26.7 m^3 of air was sampled at a flow rate of 40 m^3/h. A 10% portion (5 cm in diameter) was removed from the filter media after collection and counted for both alpha and beta-gamma activity in the PC counter. Concentrations of radon (^{222}Rn), thoron (^{220}Rn), and the presence of any long-lived

airborne radionuclides were determined based on the result of several counts of each sample at specified intervals.

Air-particulate samples were also collected on Millipore Filter media for 40 minutes at a flow rate of approximately 1.5 m^3/h. A portion of each filter sample was used for alpha spectral analysis to determine the actinon (^{219}Rn) concentration.

Details of air-sampling techniques and associated calculations are given in Appendix 3.

Soil Corings

Environmental soil samples (4-in-diameter by 12-in-deep corings) were taken from selected undisturbed locations (Fig. 7). Duplicate corings were taken at two additional sites, private residences in Albany (Fig. 1), to determine background levels of radionuclides in the soils of the area. Uranium and gamma spectral analyses were conducted on all samples.

The samples were collected using a 4-in-diameter, 6-in-long right-circular-cylinder cutting tool, commonly used as a golf-green hole-cutter. Each soil core was 12-in long and was divided into four segments for analysis. Starting from the surface, three, 2-in segments were cut, bagged, and marked A, B, and C, respectively; the final segment of 6-in was marked D.

The segmented coring technique was used to determine if any contaminant migration had occurred; to reduce the dilution of lower-level soil with the upper-level segments with respect to the surface deposition of the contaminants, or vice versa; and to reveal if any overburden or backfill had been added.

Soil Borings

Bore holes were drilled in areas exhibiting elevated radiation levels (Fig. 8). Samples were taken from the hole in sequential 1-ft sections using a split-spoon sampler (1½-in inside diameter). The depth of the bore holes ranged to 10 ft. The bore holes were identified by a number (e.g., 7-S41), and each sample was identified according to depth in feet (e.g. 7-S41-2.0 equates to bore hole 7-S41 sample from 1.0 to 2.0 ft below the surface). Depths were reported to the nearest tenth of a foot.

Soil Analyses

Soil samples were prepared at ANL as detailed in Appendix 4 and shipped either to a commercial laboratory (LFE Environmental Analysis Laboratories) or to the Analytical Chemistry Section of the Chemical Engineering Division at Argonne National Laboratory for radiochemical and gamma-spectral analysis.

ANALYSIS OF SURVEY RESULTS

General

The percentages of the total floor and wall areas accessible for survey within the buildings are shown in Table 1. The gas-flow proportional-counter survey instrument data were converted to surface contamination measurements according to the following general procedures (also see Appendix 2). For gross readings taken in the beta mode, background and any alpha contribution were subtracted to determine the net beta-gamma count rate. The net count rate was then converted to disintegrations per minute (dis/min) and normalized to a surface area of 100 cm^2. After subtraction of background, readings in the alpha mode also were converted to dis/min-100 cm^2. These results are reported in Table 1.

Smear samples were counted for both alpha and beta-gamma activity and the net count rates are converted to dis/min-100 cm^2 after subtracting the appropriate background.

Low-energy x-ray and gamma exposures were measured with the PRM-5-3. The results are reported in counts per minute (cts/min) and include the instrument background of 500 cts/min. The GM detector and μR meter exposure rate measurements given in Table 1 include the instrument backgrounds of 0.03-0.05 mR/h and 5-7 μR/h, respectively. The beta-gamma levels varied somewhat, due primarily to the construction materials in each room.

An average exposure reading was determined in the buildings where floor and wall surveys were performed. This reading is recorded in Table 1 in the "Radiation Exposure Level (1 meter)" column. The radiation levels in this column, which are reported in units of mR/h, were measured with a GM detector or a μR meter. Additionally, an integrated background measurement of the ambient radiation field at select locations was taken with a pressurized ion chamber.

Instrument measurements greater than the instrument backgrounds are presented in Table 1. The locations where these measurements were recorded are shown in Figures 9 through 33.

The instrument survey data and the smear results were reviewed with respect to both the ANSI Standard N13.12, "Control Of Radioactive Surface Contamination of Facilities To Be Released for Uncontrolled Use," and the NRC's "Guidelines for Decontamination Of Facilities And Equipment Prior To Release For Unrestricted Use Or Termination of Licenses For By-Product, Source, Or Special Nuclear Material" (see Appendix 6).

Since normal thorium was identified in some buildings, the acceptable surface-contamination levels for ^{232}Th have been used for purposes of comparison. The ANSI Standard allowable ^{232}Th activity is 200 dis/min-100 cm^2 removable; the total (fixed plus removable) alpha activity can be 2000 dis/min-100 cm^2, but the beta-gamma activity must be undetectable when measured with an instrument that shall be calibrated to measure at least 100 pCi with the contaminant uniformly spread over 100 cm^2.

According to the NRC Guidelines, the average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm, and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 mg/cm^2 of total absorber.

Instrument and Smear Surveys

Buildings

Contamination was found in 10 of the 33 buildings surveyed. Most of the contamination consisted of small spots ($\cong$ 1 x 10^3 cm^2). The highest beta-gamma level of contamination inside the buildings (1.5 x 10^5 dis/min-100 cm^2) was a spot on the floor at location 217 in Room 1 of Building 27. The highest alpha level, 2.4 x 10^4 dis/min-100 cm^2, was found in Building 23 at location 225 in a floor trench. The highest end window contact exposure reading of 1 mR/h found inside a building was a spot on the floor at Location 217 in Building 27.

Smear surveys indicated the presence of loose contamination (reported as normal thorium) at 21 locations in 5 buildings. Results of the smear surveys are given in Table 2.

Areas inside buildings where contamination exceeded acceptable surface contamination levels as given in the ANSI Standard or the NRC Guidelines (see Appendix 6) are identified in Table 3. These areas are indicated in Figures 9 through 33.

Lawns, Roadways, and Docks

During the surveys of lawns, roadways, and docks, several areas of contamination were found, including about 60 areas exceeding the acceptable surface contamination levels as given in ANSI N13.12 or the NRC Guidelines (see Appendix 6). These areas are identified in Table 3, and the locations are shown in Figures 34 and 35.

In most instances, contamination in exterior concrete surfaces surveyed consisted of small, localized spots (1×10^3 cm^2). However, much of the contamination found in the lawn was not localized, and areas of general contamination were discovered. The largest such area was at location 29; it consisted of a surface area of 1.5×10^5 cm^2 with a maximum reading of 5.9×10^3 dis/min-100 cm^2 $\beta\gamma$.

The highest beta-gamma reading in the lawn was 1.2×10^6 dis/min-100 cm^2 at location 1 (3×10^3 cm^2); the highest alpha reading on the lawn was 2.2×10^3 dis/min-100 cm^2 at location 3 (3×10^4 cm^2). The highest GM End Window exposure reading on the lawn was 1.0 mR/h at contact at location 21.

The highest beta-gamma and alpha readings on the docks or on the outside of buildings were found on the side of Building 31 at location 28 (1×10^3 cm^2). The beta-gamma reading was 1.7×10^5 dis/min-100 cm^2, and the alpha reading was 1.7×10^4 dis/min-100 cm^2. The highest GM End Window contact exposure reading was 3.0 mR/h on an asphalt dock at Location 23.

Seventeen of the smears taken on the lawns, roadways, and docks indicated the presence of loose contamination. Results of the exterior smear surveys are presented in Table 2.

Sanitary Sewers

Since contamination was found in the floor trenches in Building 31, it was deemed necessary to survey for contamination in the connecting sanitary sewers.

Portable instruments were used to survey sewers both upstream and downstream from the AMRC (see Fig. 4 for locations of these sewers). A gamma spectrum was also taken in the sewers to see if any contamination above natural background levels could be detected. No contamination was noted with the instrument surveys, smears, or the gamma spectrum of the sewers.

Albany Waste Treatment Plant and Ohling Farm

No elevated levels of radioactivity were detected by the instrument surveys of fields at the Ohling Farm. Instrument surveys were not conducted at the Albany waste treatment plant.

Septic System

Contamination was found at the septic tank inlet (Fig. 3) in the drain tile field behind Buildings 12 and 17. The PRM-5-3 reading at 15 cm above the water level in the tank was 2.0×10^4 counts/min (background of 500 cts/min). The reading at the grill of the inlet was 1.0×10^4 to 1.5×10^4 counts/min with the PRM-5-3; the dirt along the side of the septic tank indicated a reading of 2.5×10^4 counts/min. No other surface contamination was detected in the drain tile field of this septic system.

Air Samples

Air samples were taken in the buildings and in the sewers. The results are presented in Table 4. The detailed calculations used in evaluating the samples are shown in Appendix 3. The radon-222 Working Levels (WL) in the buildings ranged from 0.0004 WL to 0.0168 WL. These values are well below the limit of 0.02 WL for average annual concentration as specified in the EPA Standard (40 CFR 192).

The air samples collected in the sewers indicated Working Levels ranging from 0.0018 to 0.1302 WL. Five air samples taken in the sewers were greater than the 0.02 WL limit. It is the judgement of the survey team personnel that these elevated levels of radon-222 are due not to contamination, but due to the movement of naturally occurring radon through the ground into the sewers where

there is little or no air exchange. No long-lived activity was detected on any of the samples. The locations at which each air sample was taken in the sewer are shown in Figure 4 (see Table 4).

Air samples were also analyzed to determine if any actinon (^{219}Rn) or thoron (^{220}Rn) was present in the sewers; neither was noted in the results of the alpha spectral analyses of these samples.

Soil Corings

Two background soil corings were taken at each of two offsite locations (see Fig. 2) to ascertain background levels of radionuclides in soil for the Albany area. These corings have been identified as 7-SB1 through 7-SB4. Soil corings were taken at various locations throughout the site to determine the presence of contamination. The soil corings taken at the site have been identified as 7-S5 through 7-S25; coring locations are shown in Figure 7. Soil corings taken at the Ohling Farm (Fig. 6) have been identified as 7-S33 through 7-S38. All soil corings were sectioned and analyzed for uranium (uranium fluorometric) as well as radium and thorium decay chains (gamma spectral analysis). Significant levels of thorium (decay chain) and uranium (normal) were found in six of the soil corings taken on the AMRC site. These results are included in Table 5. No elevated levels of radioactivity were detected in the corings from the Ohling Farm.

Soil Borings

Subsurface investigations using soil boring techniques were conducted within all the contaminated areas at the site. A total of 48 bore holes were drilled to depths up to 10 ft. Bore holes identified as 7-S41 through 7-S55 were taken in the drain tile field (see Fig. 3). Bore holes identified as 7-S99 through 7-S131 were taken from other suspect areas at the site. The location for each of these bore holes is shown in Figure 8. Detailed drawings showing the exact location of each bore hole are presented in Figures 36 to 39. Split-spoon samples were taken from these bore holes at continuous 1-ft increments. Bore-hole logging was accomplished using a 2x2-in NaI(Tℓ) detector in conjunction with a ND-100 multichannel analyzer, a teletype printer as the

hardcopy readout, and punched tape storage. Readings were taken at grade level and at 2-ft increments thereafter. Analyses of soil samples taken from the bore holes and the soil corings revealed significant levels of radioactive materials. The levels ranged up to 6 pCi/g for the radium series and up to 637 pCi/g for the thorium series. Uranium concentrations as determined by uranium fluorometry ranged up to 36 pCi/g. This elevated activity was found primarily in the first foot of soil.

The many analyses conducted on the samples have indicated some discrepancies between the gamma spectral results and the uranium fluorometric results. When the ^{226}Ra concentration, as determined by gamma-spectral analysis, appears greater than about half the uranium concentration, as determined by the uranium fluorometric analysis, this is indicative of radium enhancement similar to that found in mill tailings. When the reverse of this is found, it is an indication that normal uranium (i.e., uranium that has been separated from its daughters) and not natural uranium (i.e., uranium in equilibrium with its daughters) is present. Both ratios were found in several of the analyses conducted for this survey, indicating that buried contaminants may be more diverse than just natural uranium and natural thorium with their progeny.

All soil samples were prepared as outlined in Appendix 4. Soil sample weights are tabulated in Table 6. Results of the uranium fluorometric analyses and the gamma-spectral analyses for soil samples are given in Table 5.

Radiochemical separation of thorium followed by alpha spectroscopic analysis was performed on select samples that contained elevated levels of thorium. This technique makes it possible to determine the relative abundances of the ^{228}Th and ^{232}Th isotopes. On this basis, inferences can be drawn regarding the extent of any chemical separations of the thorium ore. Two of the samples (7-S22 and 7-S23) showed an excess of ^{228}Th over ^{232}Th indicating that the contamination was primarily due to the mesothorium (^{228}Ra) chain (i.e., separated daughters of ^{232}Th). The results of these analyses are given in Table 7.

Water and Sludge Samples

As indicated previously, water and/or sludge samples were collected from the septic tank and from selected bore holes on the site, and from nearby sewers and from the Albany waste treatment plant off the site. All the samples were analyzed by the uranium-fluorometric technique, and some were additionally

analyzed by the gamma spectrometric technique. The results are given in Table 8. Selected samples were also analyzed by the thorium radiochemical technique. These results are included in Table 7.

The sludge sample (7-S82) taken from the onsite septic tank showed greatly elevated levels of ^{232}Th decay chain as well as normal uranium. The water sample (7-W83) taken from the tank showed elevated levels of uranium (normal), as well as an excess of ^{228}Th indicating the presence of the mesothorium (^{228}Ra) chain. No abnormal levels of radioactivity were found in the four water samples (7-W84 through 7-W87) taken from bore holes 7-S48, 7-S49, 7-S52, and 7-S55, respectively.

The water samples (7-SS41 through 7-SS50) from the sewers did not show any contamination; however, the sludge samples (7-SS51 through 7-SS59) showed elevated levels of normal uranium (see Table 8) and mesothorium (see Table 7).

The water samples (7-SS60 through 7-SS67) taken from the Albany waste treatment plant showed background levels except for sample 7-SS67 (100 pCi U/g). However, since this sample was taken from the phosphate tank, the uranium might be expected to concentrate in that waste-treatment process step. The results of the analysis indicate that this contamination is normal rather than natural uranium.

ESTIMATED EXTENT OF CONTAMINATION

Interior surface contamination was found in ten buildings. An estimated total surface area of (13 m^2)spread over 44 locations was found to be contaminated. The largest area of contamination (10 m^2) was in Building 27 (see Table 3).

Outside the buildings, surface contamination was found at 26 locations totaling 31 m^2 on unpaved areas, and at 33 locations totaling 12 m^2 on paved areas (see Table 3). The largest areas of contamination were 15 m^2 at spot number 29 in the unpaved area and 6 m^2 at spot 37 in the paved area.

Bore holes were only drilled in the unpaved areas; hence the estimate of the extent of subsurface contamination is based only on these areas and is subject to uncertainties. The contamination seemed to be generally restricted to the first foot of soil. In three cases (bore hole 7-S116, 7-S121, and 7-S128)

there was significant contamination at the 2-ft level and observable contamination at the 3-ft level. In six other cases, there was observable contamination at the 2-ft level (see Table 5).

For this evaluation it has been assumed that contamination extends to a depth of 0.61 m (2 ft) in both the paved areas (12 m^2) and the unpaved areas (31 m^2) found to be contaminated. On this basis, the total volume of contaminated (exterior) material is calculated to be 26.2 m^3. The maximum and average measured concentration of each radionuclide chain in areas outside the buildings, was as follows (see Table 5):

Location	Maximum (pCi/g)	Radionuclide	Average (pCi/g)
7-S10-A	2	^{226}Ra chain	2
7-S10-A	673	natural thorium	67
7-S55-2	2	natural uranium	2
7-S23-A	36	normal uranium	9

Hence, for these calculations it can be assumed that the contamination is attributable to natural thorium and normal uranium only (2 pCi/g for natural uranium and the ^{226}Ra chain can be considered background levels).

On the basis of these data and assumptions, it has been estimated that the extent of exterior contamination includes 26.2 m^3 of material with a mass of 3.9×10^4 kg and an activity of 0.027 Ci. More detailed estimates are presented in Table 9, and the methods of calculation are shown in Appendix 7.

DOSE AND POTENTIAL HAZARD EVALUATION

External Exposure

To assess the radiological hazard from external exposure to the radiation sources, a "conservative" (or worst-case) situation was assumed. Since commercial, rather than residential occupancy is involved, it was assumed that an individual would be exposed 40 hours per week to the maximum interior or exterior radiation levels.

The maximum interior radiation level observed was 1 mR/h (contact) in Building 27, and the maximum exterior radiation level observed was 3 mR/h

(contact) on the dock adjacent to Building 31. The annual radiation doses from these sources would be:

Interior: 1 mR/h x 40 h/w x 52 w/y x 1 rem/R = 2.08 rem/y
Exterior: 3 mR/h x 40 h/w x 52 w/y x 1 rem/R = 6.24 rem/y.

These doses are based on the contact radiation level and hence overestimate the dose to a person occupying the area. Furthermore, the likelihood of a person's occupying one spot for 40 hours per week is extremely remote. Hence, it is our judgement that the contaminated areas of this site do not constitute an immediate radiological hazard in terms of external exposure, even though these two worst-case doses are significantly above the DOE 5480.1 limit of 500 millirem per year for a person non-occupationally exposed[1] (see Appendix 6).

Internal Exposure

To assess the potential for radiological hazard based on potential internal exposure, it was necessary to assume some "conservative" but nevertheless plausible scenarios whereby the radioactive contamination was assimilated internally. To this end, two cases were considered. The first case was based on a situation in which a child would eat 100 g per year of contaminated soil. For the second case, a person was assumed to rototill the contaminated soil (dry) to a 1-ft depth for a working day (eight hours) once a year. For this latter case, a resuspension factor of 10^{-6} m^{-1} and a breathing rate of 9.6 m^3/working day[2] were used. In both cases it was assumed that the average concentration of contaminants in the soil was equal to the maximum measured value (a conservative assumption). All calculations are based on methods outlined in ORNL/NUREG/TM-190, Vol. 3.[3] These calculations approximate the ICRP-30 guidelines for hazard analysis.

The maximum concentrations of soil contaminants found were 673 pCi/g thorium (^{232}Th decay chain), and 36 pCi/g normal uranium (i.e., uranium exclusive of its natural daughters). Based on these levels of contamination, the following hazard levels (50-year dose commitment for one year of intake) were calculated:

Erratum
p 15
ingestion of normal
maximum.
dose is .0003 mrem/pCi
⇒ 1.1 mrem

1. Child eatir
(units: mr

natural thc

arem

normal uran

:em

2. Adult inhal
(units: mr

natural tho

m

normal uran

This radiol d be considered when any subsurf... ...k is undertaken or if children are allowed to play in the area (see Appendix 8).

CONCLUSIONS AND RECOMMENDATIONS

Buildings (Interior Contamination)

The radiological survey of the interior of the buildings revealed ten buildings with surface contamination amounting to about 13 m^2. This contamination is spread over about 44 locations (see Table 3 and Figures 9 - 33). However, the major source of the interior contamination (10 m^2) is in Building 27. The maximum contact radiation reading was 1 mR/h; however, most of the contaminated areas were considerably below this level. Air samples taken inside the buildings indicated levels of radon (^{222}Rn) progeny that ranged from 0.0004 to 0.0168 Working Levels (WL). The highest value (0.0168 WL) was found, as

expected, in the Ore Room in Building 23. All other values for Working Level were below the limit of 0.02 WL for average annual concentration as specified in the EPA Standard (40 CFR 192).

Although the interior contamination in these buildings does not pose an immediate hazard, it is our recommendation that in keeping with the ALARA philosophy, the contaminated areas should be decontaminated.

Exterior Contamination

Exterior surface contamination was found at 26 locations totaling 31 m^2 on unpaved areas and at 33 locations totaling 12 m^2 on paved areas (see Table 3 and Figures 34 and 35). Apporximately half (15 m^2) of the contaminated unpaved area was found at one location (spot 29) and about half (6 m^2) of the contaminated paved area was also found at one location (spot 37). The maximum contact radiation reading was 3 mR/h; however, most of the contaminated areas were considerably below this level.

The vertical component of the contamination was generally restricted to the first foot of soil, although in some cases contamination was found at the 2-ft level and in three cases, a limited amount of contamination was found at the 3-ft level.

The contamination consisted primarily of natural thorium with lesser amounts of normal uranium. In a few cases, the thorium showed an excess of ^{228}Th over ^{232}Th, indicating that some of the contamination was attributable to the mesothorium (^{228}Ra) chain (i.e., separated daughters of ^{232}Th).

Each bore hole was logged with a 2-in x 2-in NaI(Tℓ) detector prior to backfilling. Levels of radiation from the soil surrounding the bore hole, if larger than those found in the bore hole samples, would result in significantly elevated readings from the logged gamma-ray spectrum. No such elevated levels were observed. Hence, conclusions regarding the source of the contamination and the concentration were restricted to the more sensitive radiochemical analyses of split-spoon samples taken from the bore holes (Table 5).

The water samples taken from the bore holes did not show abnormal levels of radioactivity. However, the sludge sample (7-S82) taken from the septic tank had elevated levels of ^{232}Th decay chain as well as normal uranium, and the water sample (7-S83) taken from the septic tank had elevated levels of normal

uranium as well as the mesothorium (^{228}Ra) chain. Hence, the entire septic field is presumed contaminated, and subsurface lateral migration of the contamination must be considered possible.

It should be noted that a hydrostatic head was encountered in all bore hole operations throughout the Albany Bureau of Mines survey. Water would generally be encountered at the 8- to 9-ft depth during the drilling operation. After 1 to 2 hours, water would rise to the 4½-ft level, and in one case, to the 1-ft level. The source of the hydrostatic head has not been identified by investigations conducted during these operations. It should also be noted that since subsurface water is directly involved with the contaminants, it is possible that the contaminants are subject to subsurface lateral migration, thus potentially expanding the area of contamination from that presently depicted.

Offsite Properties

The Ohling Farm is judged to be free from contamination.

The Albany sewage treatment plant seems to be free from contamination;, however, the phosphate tank showed elevated levels of uranium (normal). The source of this uranium should be determined.

The water samples from the sewer lines were free from contamination; however, several of the sludge samples (particularly 7-SS53 and 7-SS56; see Table 8 and Figure 4) had elevated levels of normal uranium as well as mesothorium (^{228}Ra). Hence, the sewer lines are judged to be contaminated.

REFERENCES

1. U.S. Department of Energy. 1981. "Requirements for Radiation Protection." DOE 5480.1, Chapter XI.

2. U.S. Department of Health, Education and Welfare. 1970. "Radiological Health Handbook." Bureau of Radiological Health, Rockville, MD.

3. U.S. Nuclear Regulatory Commission. 1981. "Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities." Vol. III. ORNL/NUREG/TM-190 V3. Prepared by Oak Ridge National Laboratory.

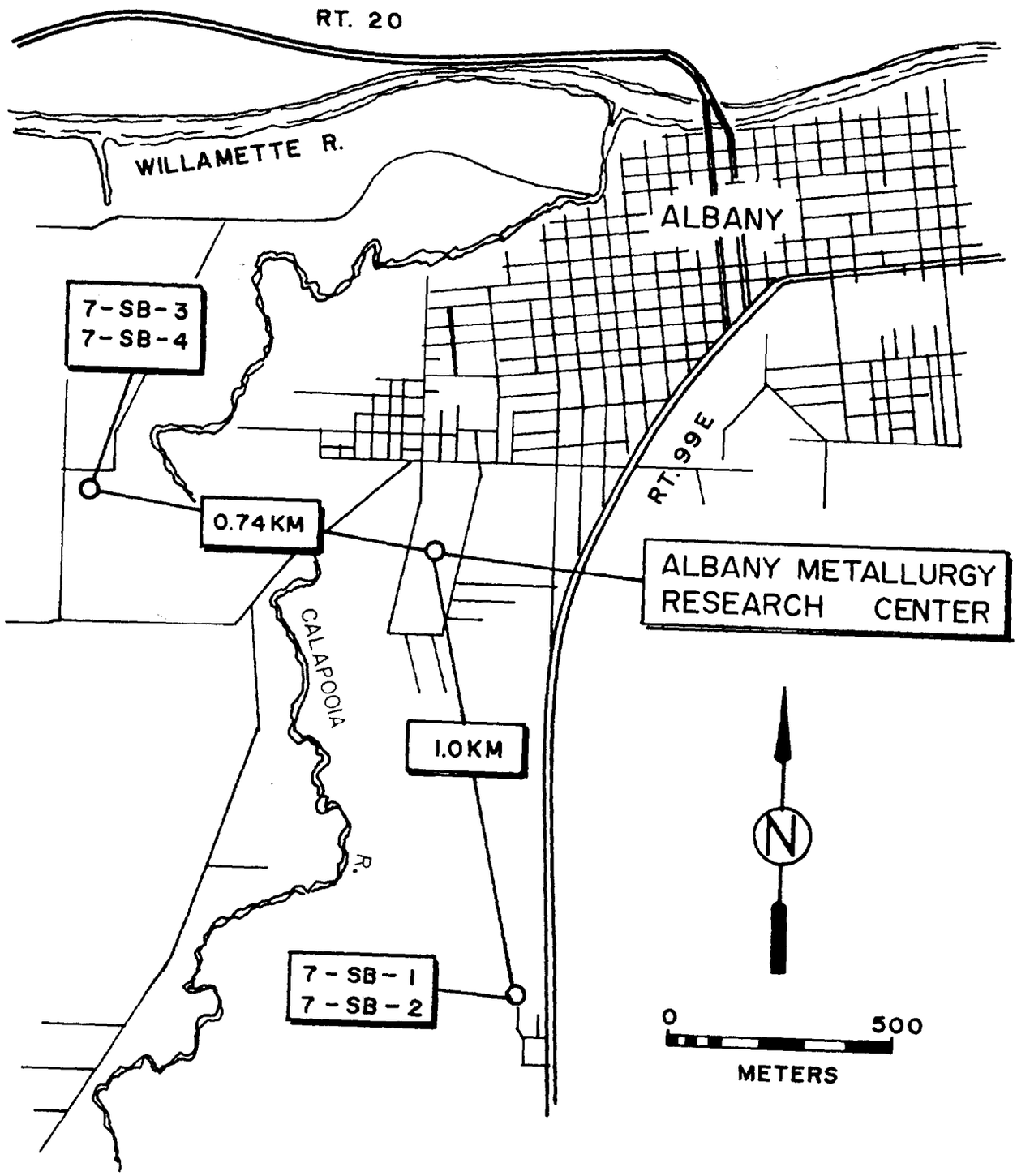

Fig. 1. Albany Metropolitan Area with Background Soil Coring Locations

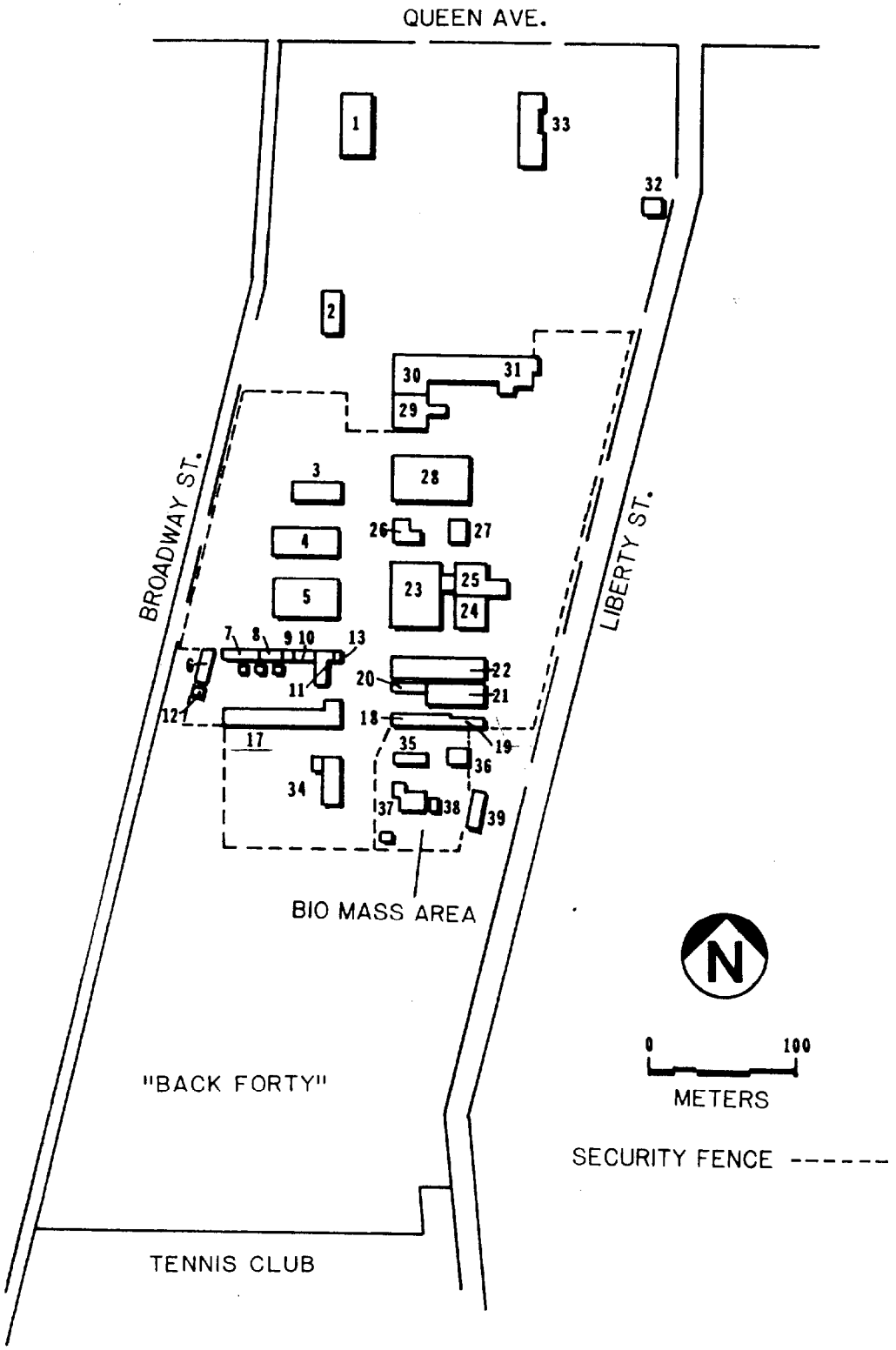

Fig. 2. Albany Metallurgical Research Center Site

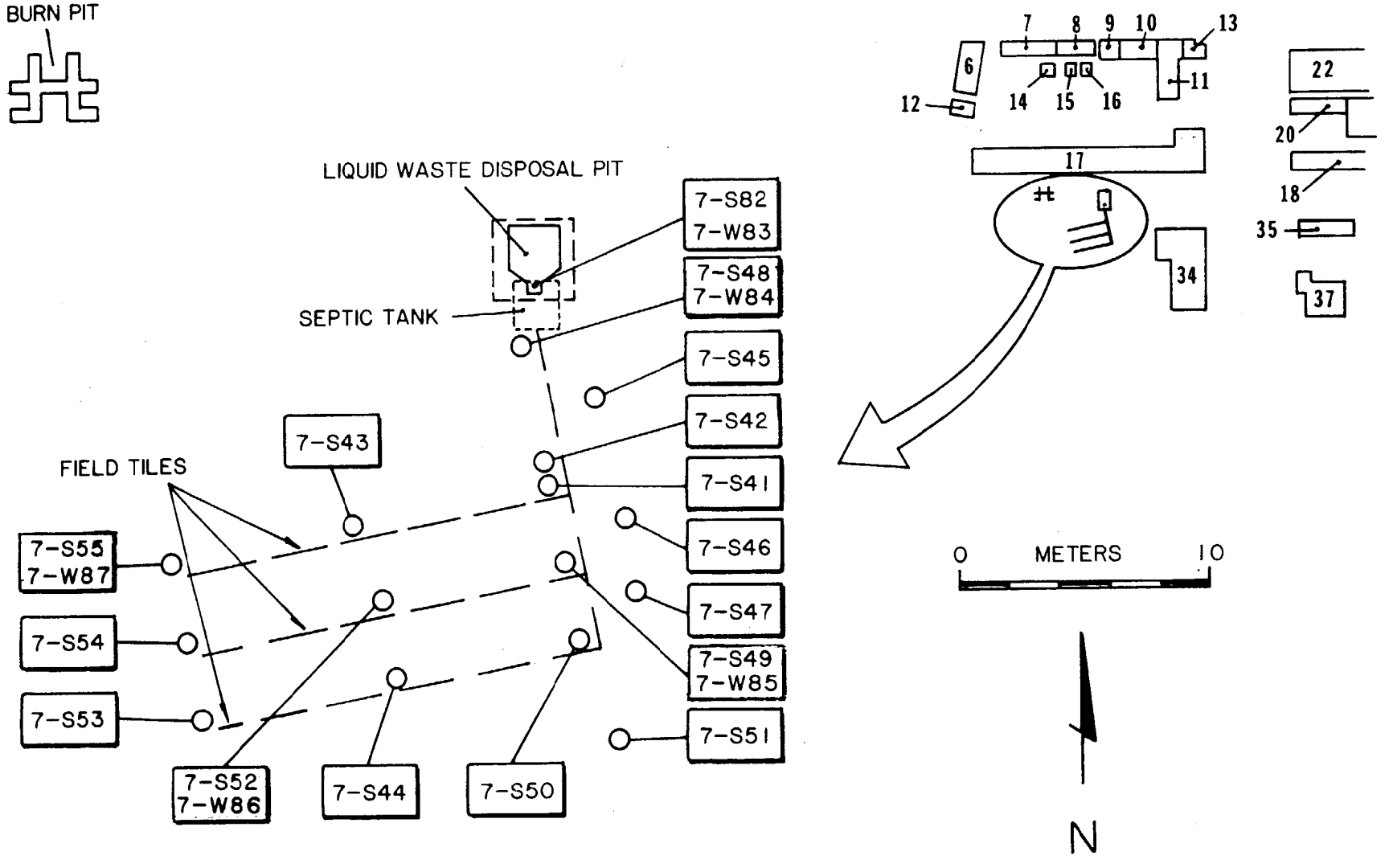

Fig. 3. Site Septic Field

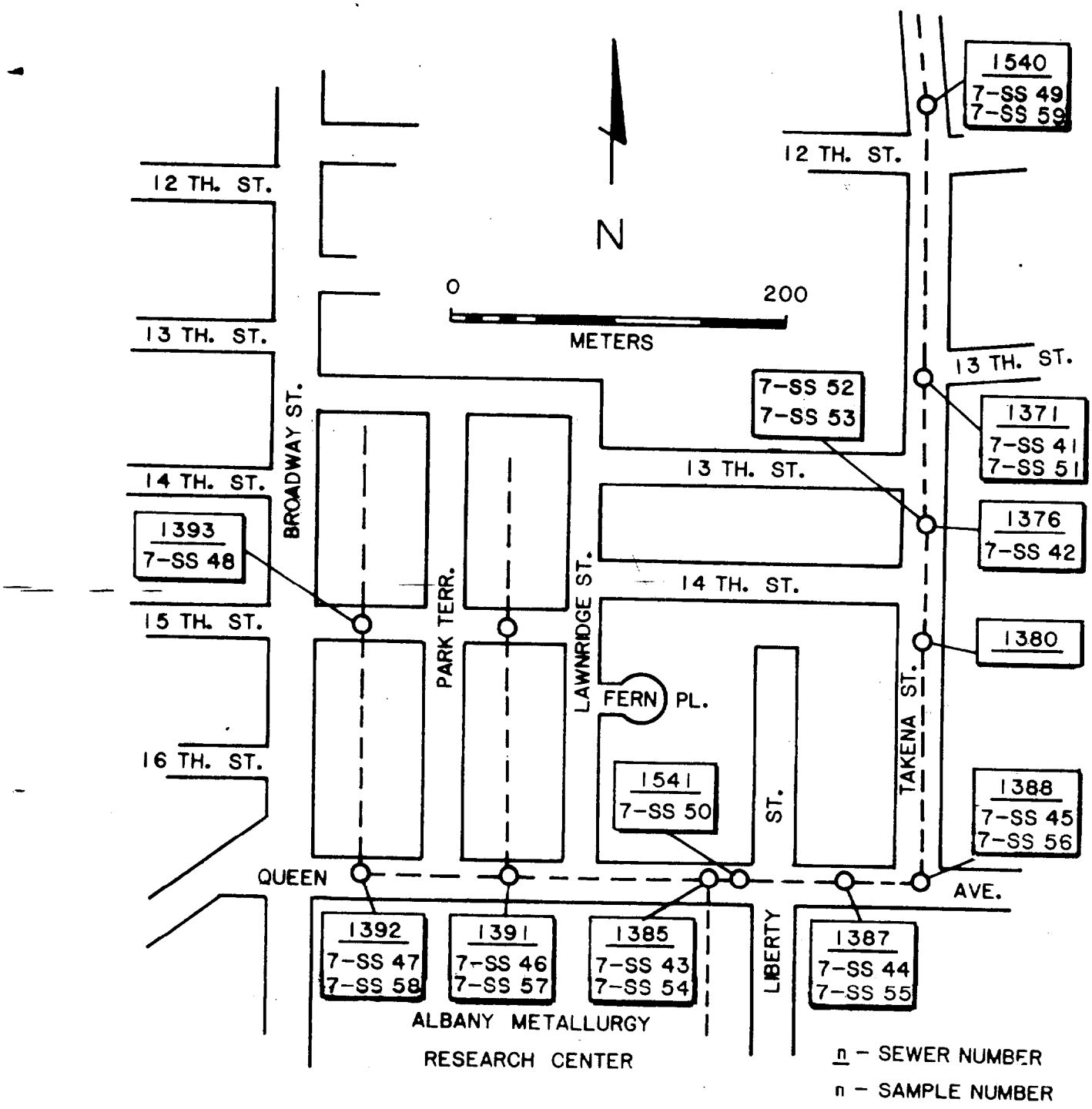

Fig. 4. Sewer System

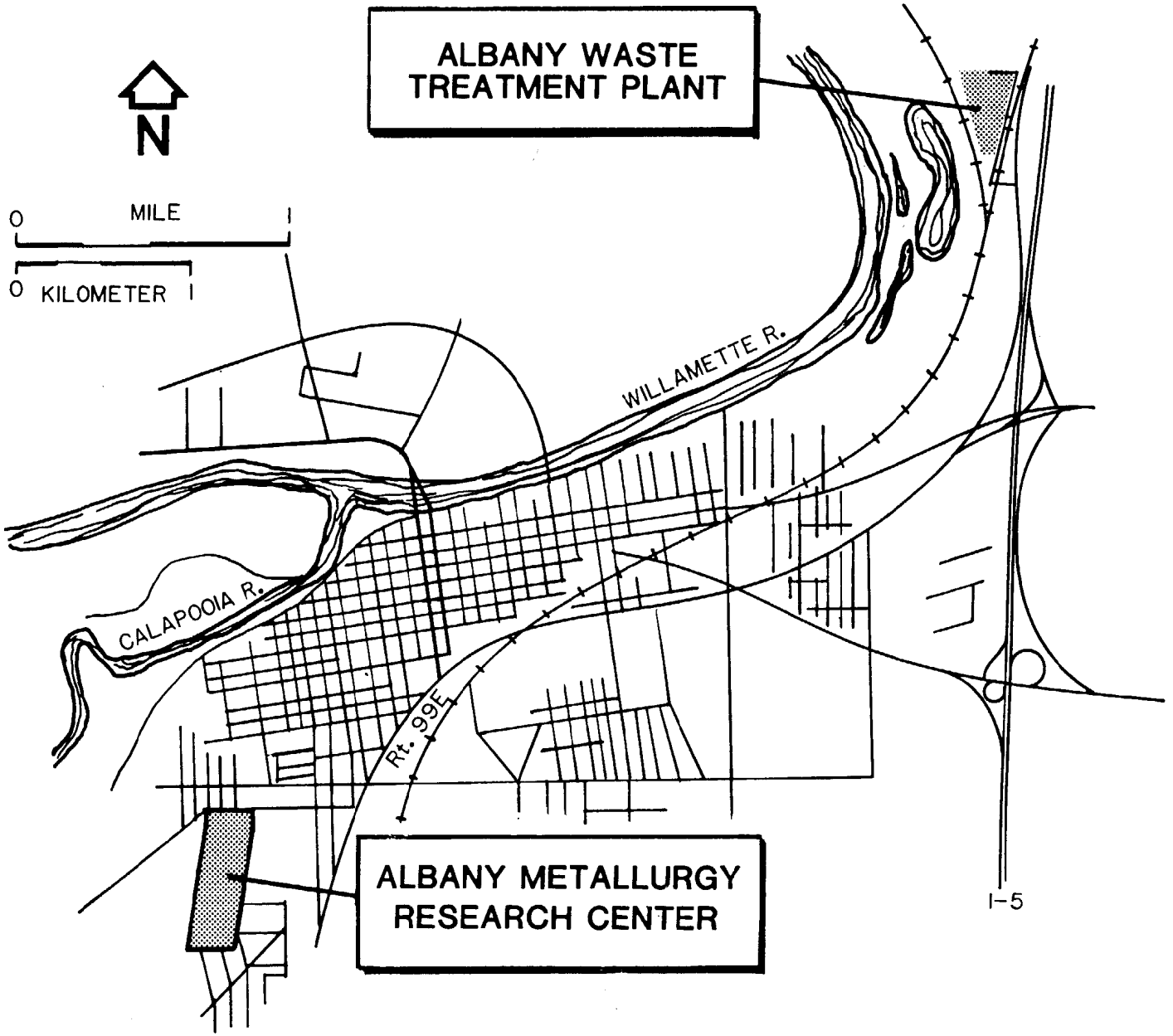

Fig. 5. Albany Waste Treatment Plant

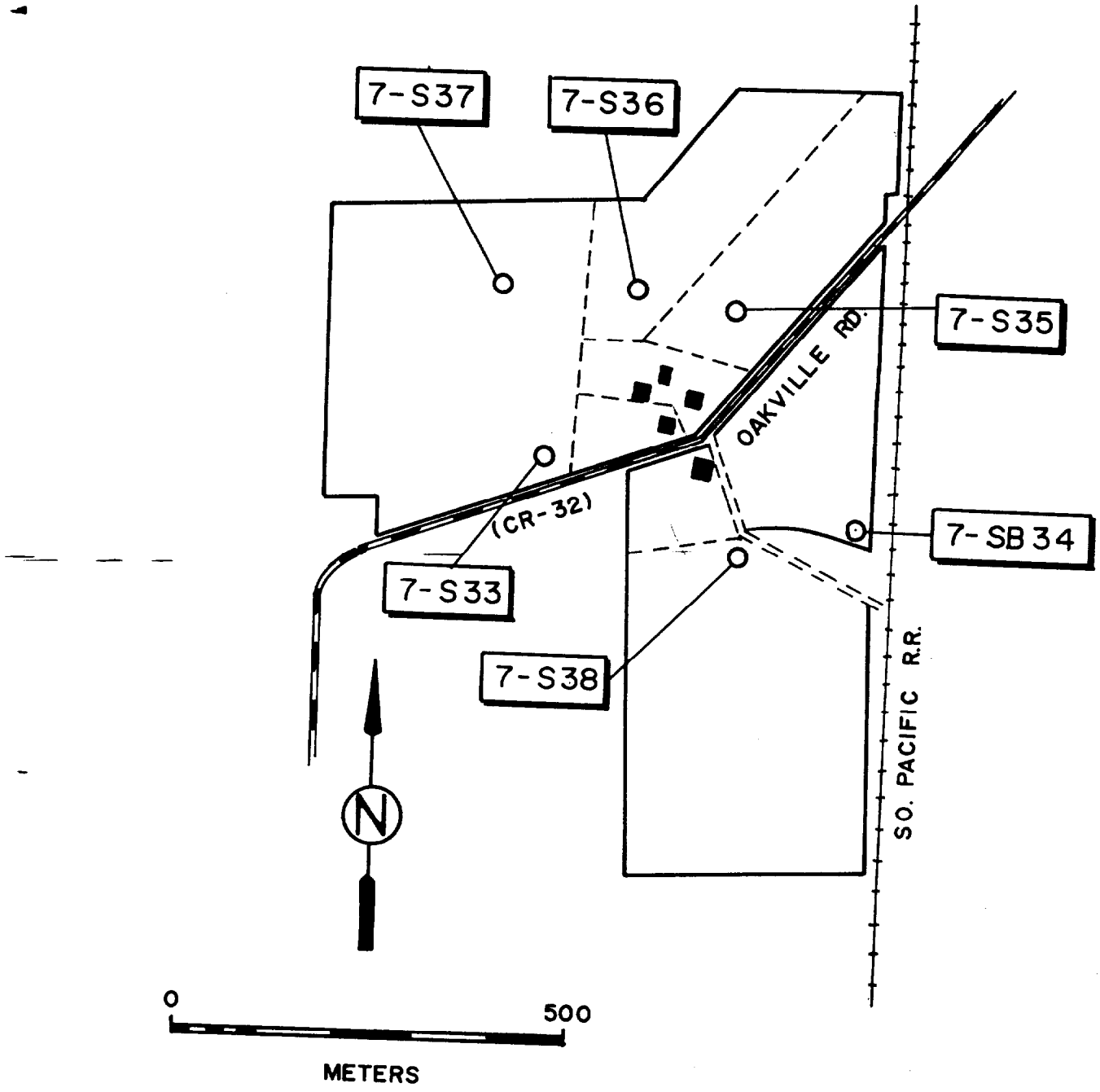

Fig. 6. Ohling Farm

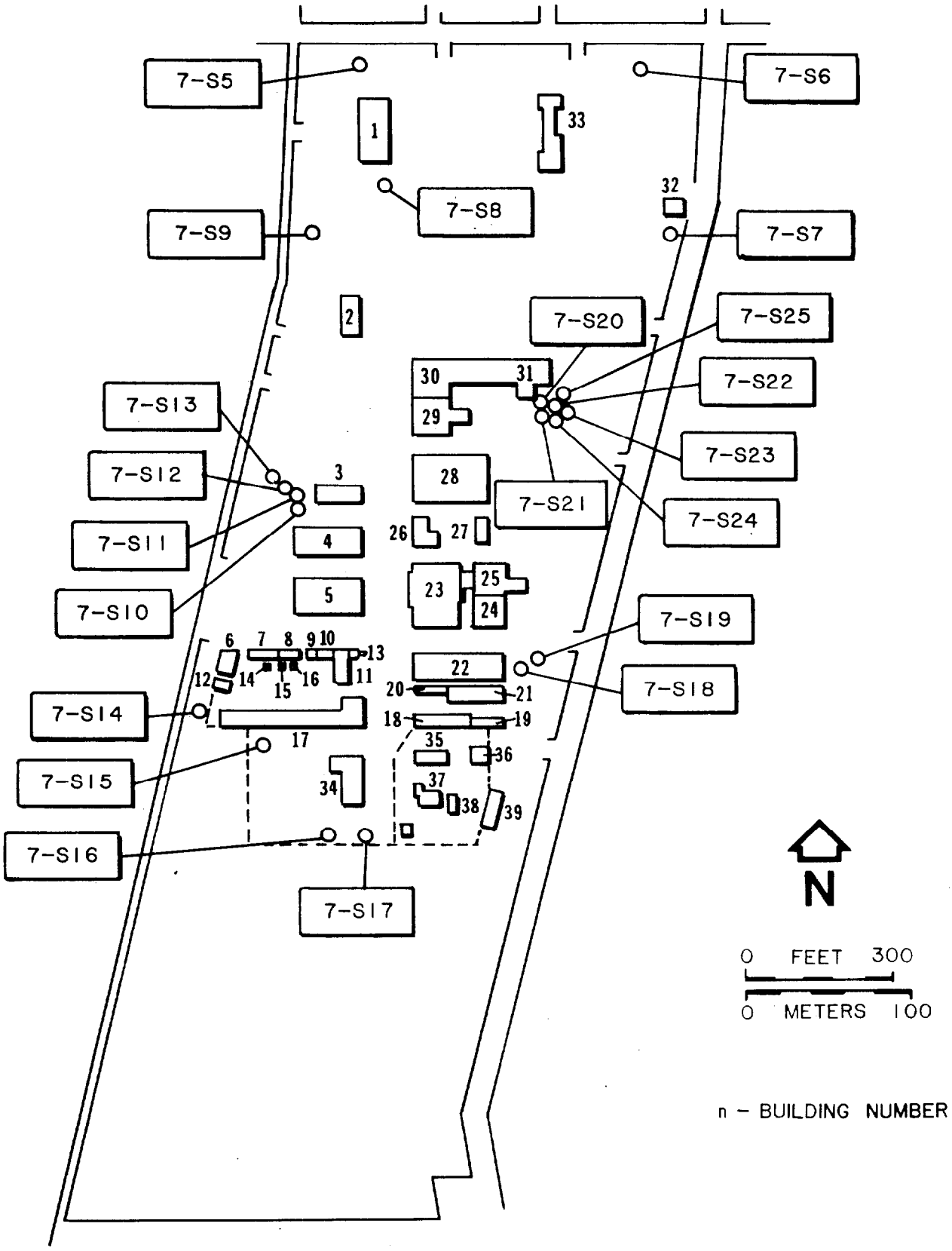

Fig. 7. Soil Corings

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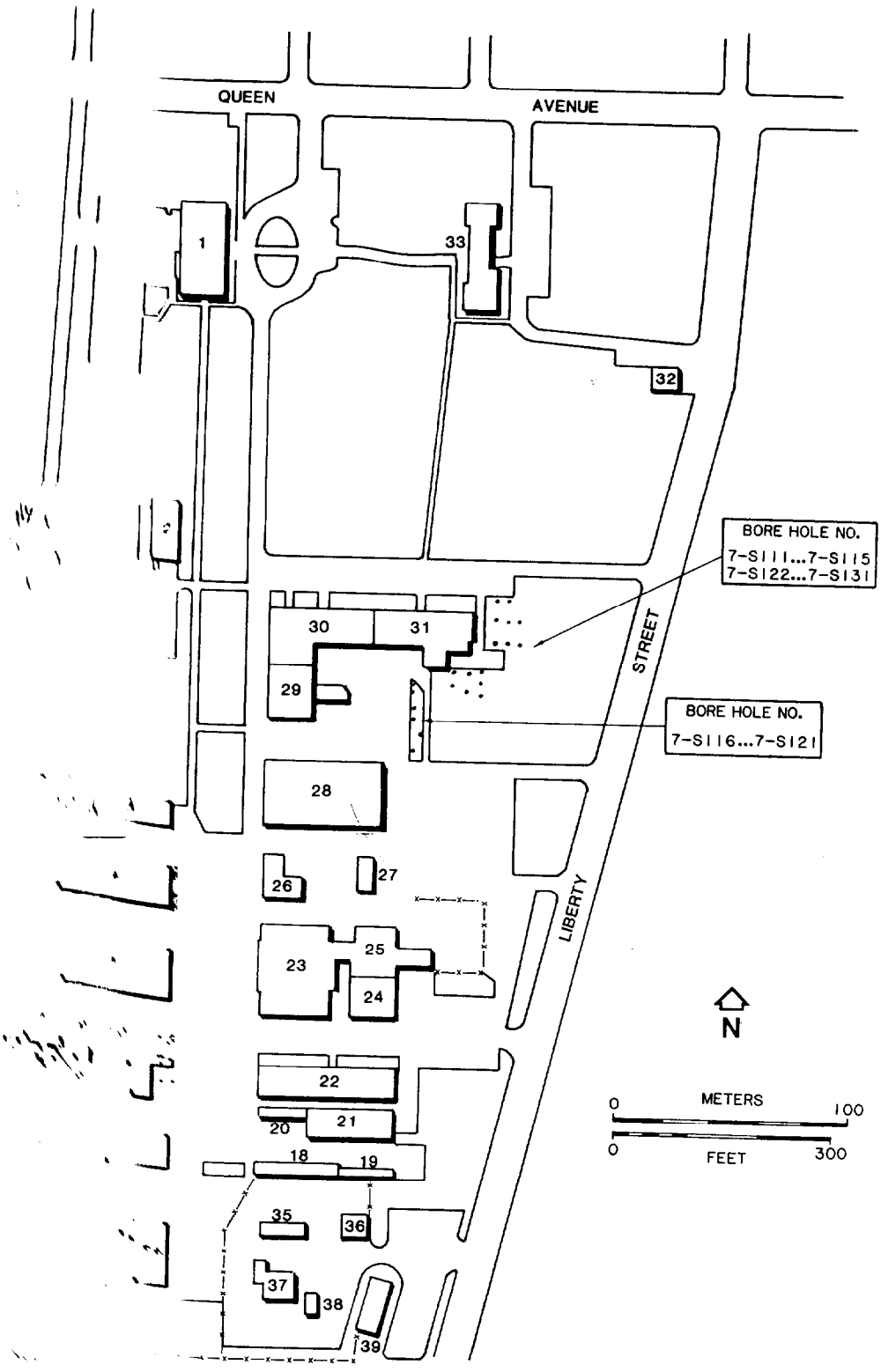


. 8. Soil Borings

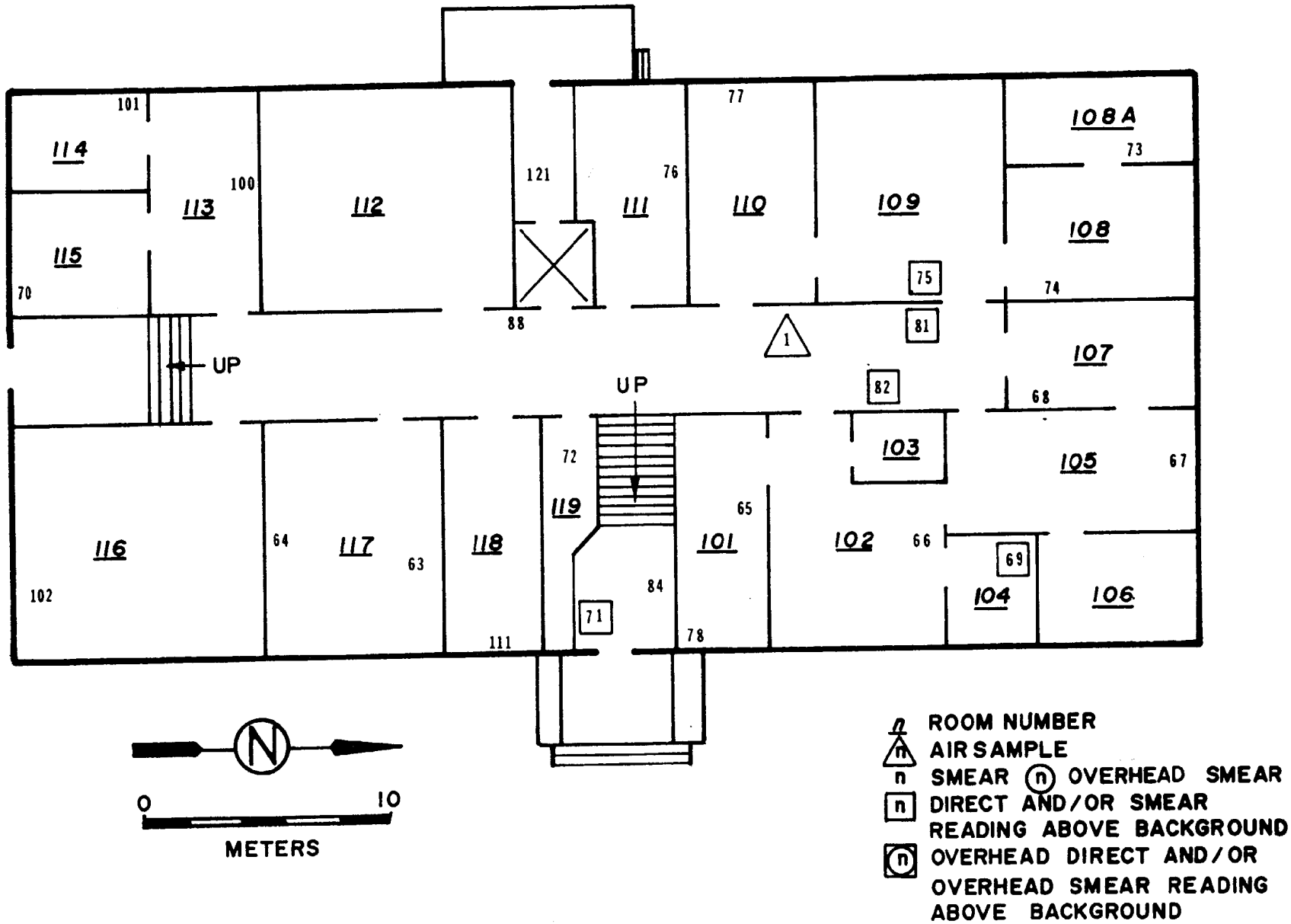


Fig. 9. Building 1, Ground Floor

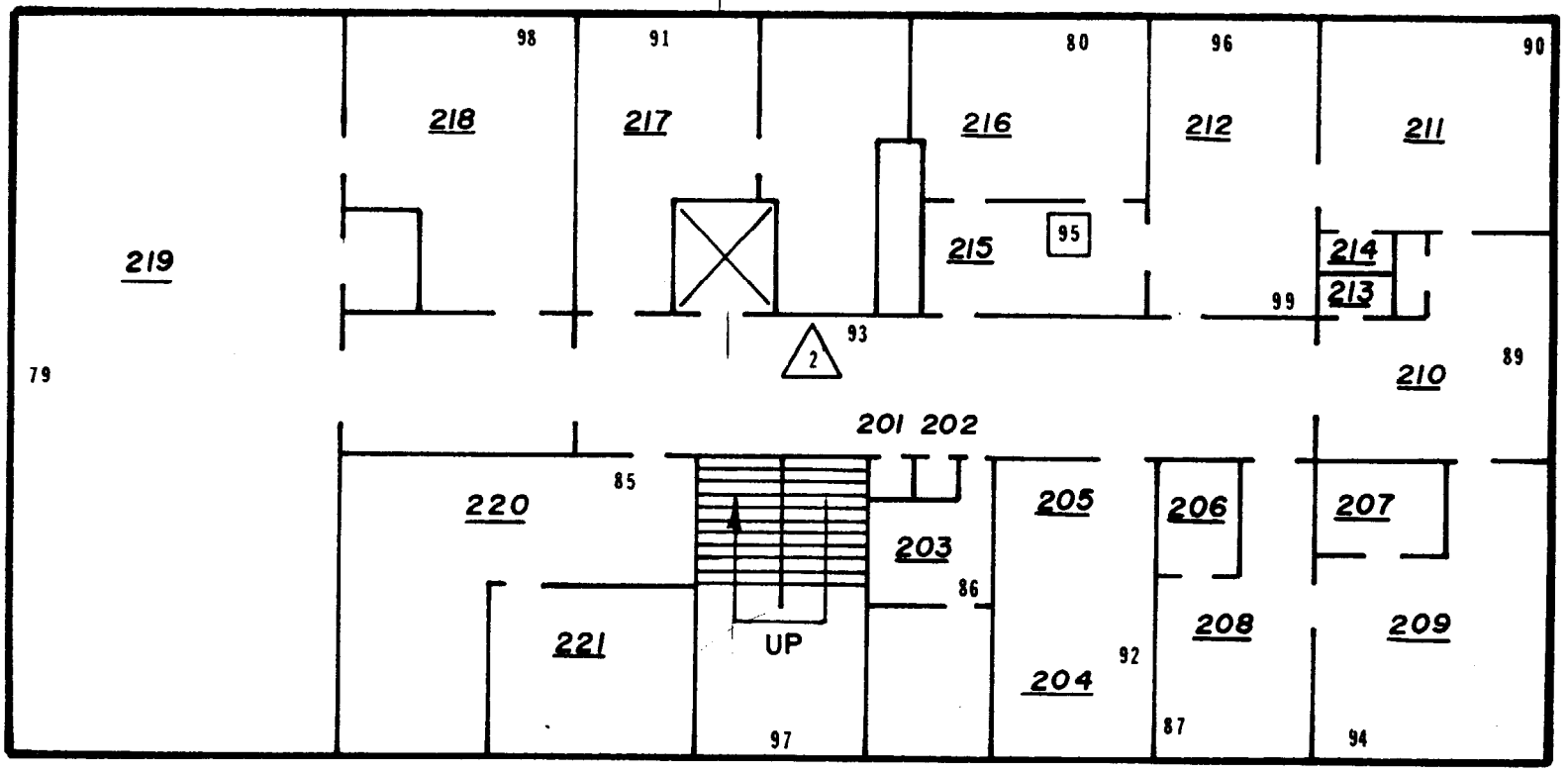


Fig. 10. Building 1, Second Floor

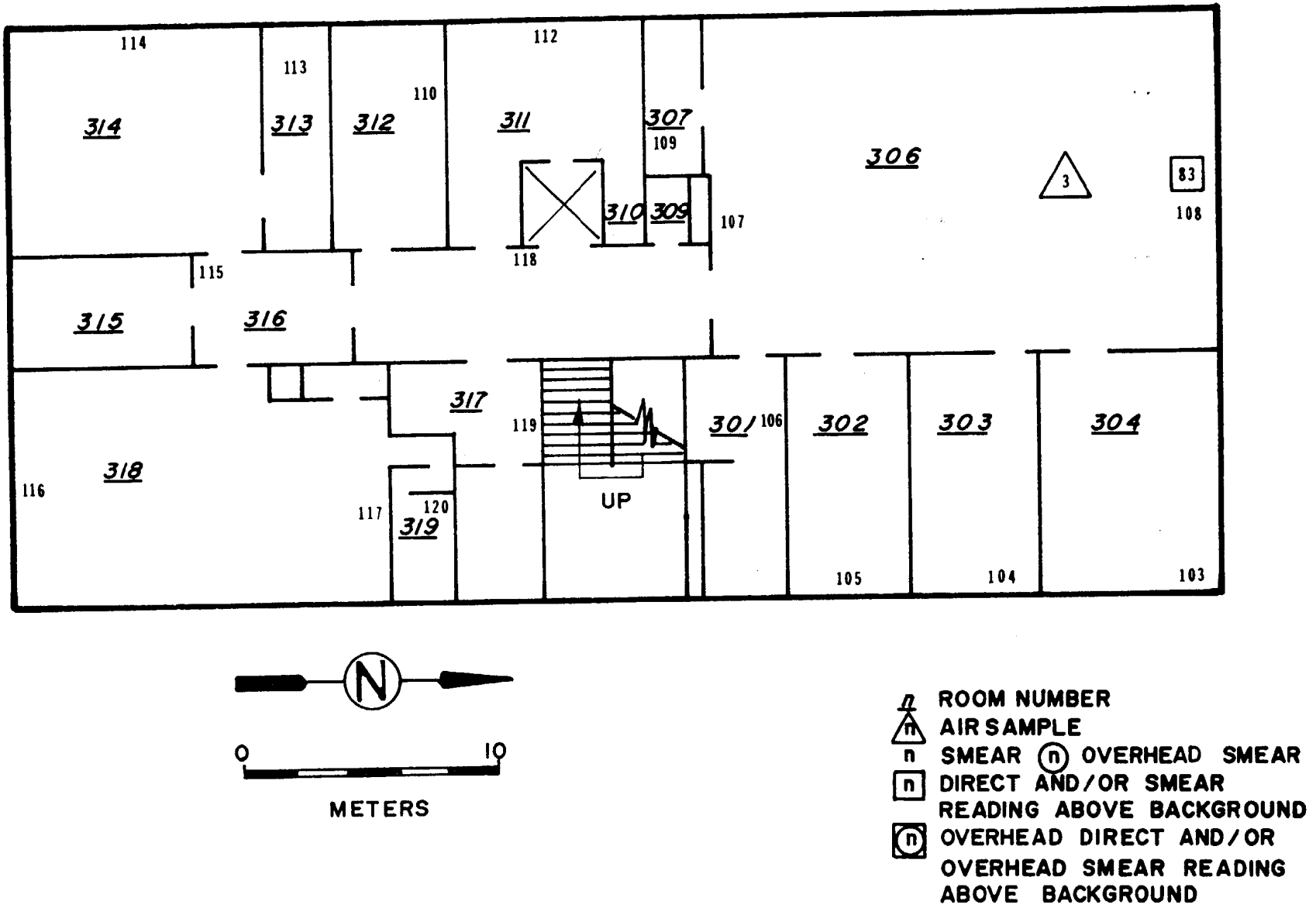


Fig. 11. Building 1, Third Floor

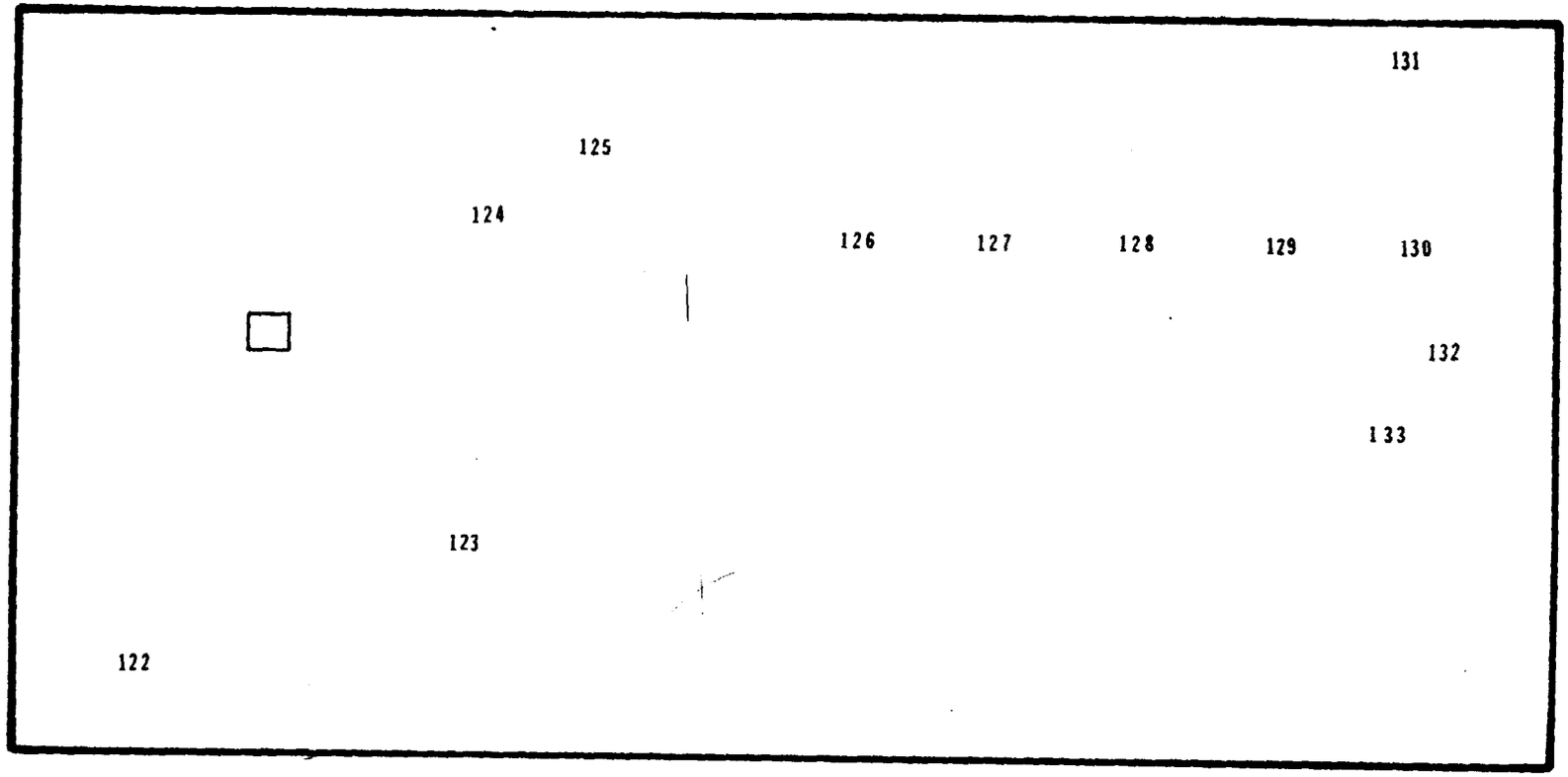


Fig. 12. Building 1

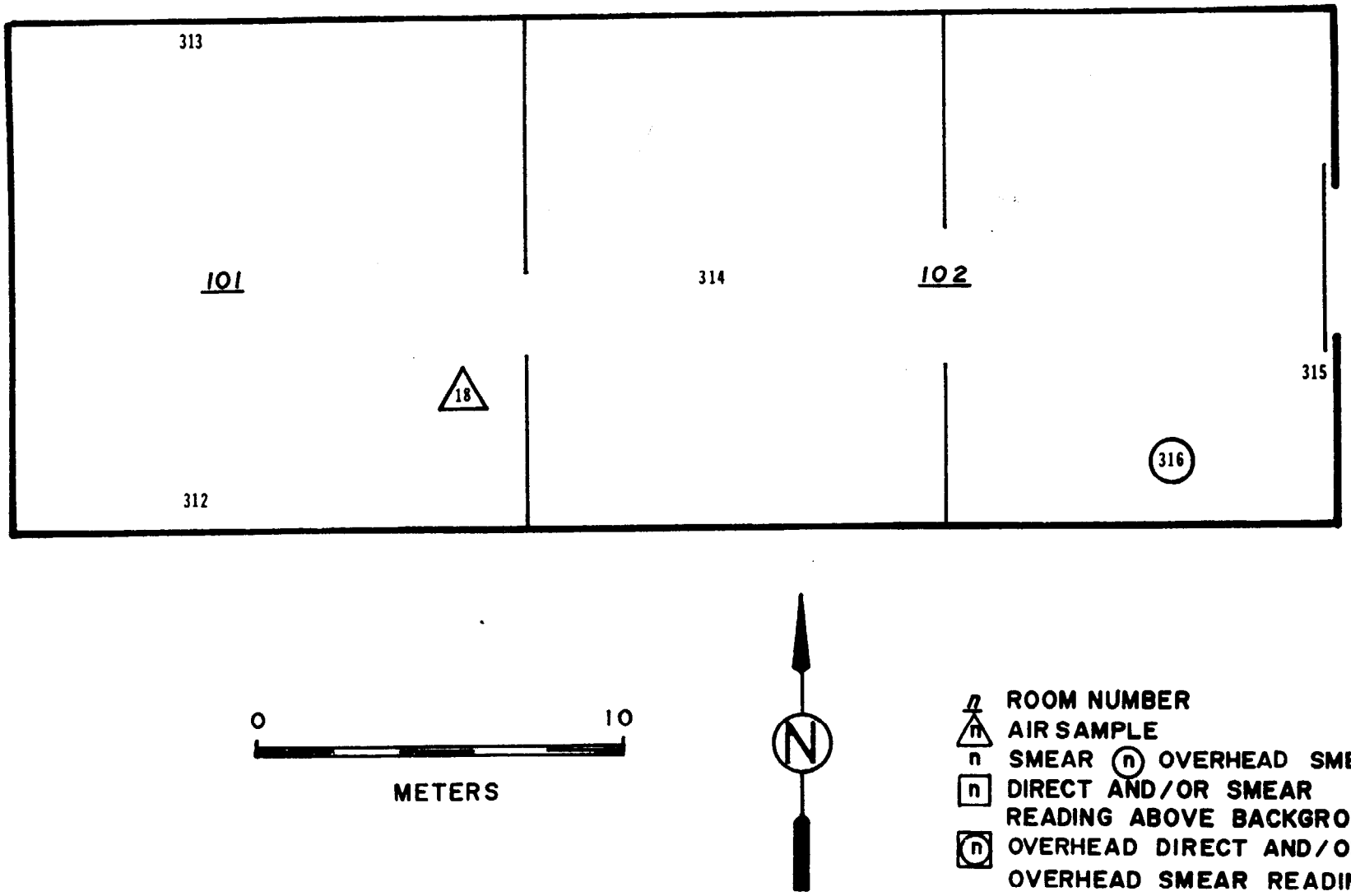


Fig. 13. Building 3

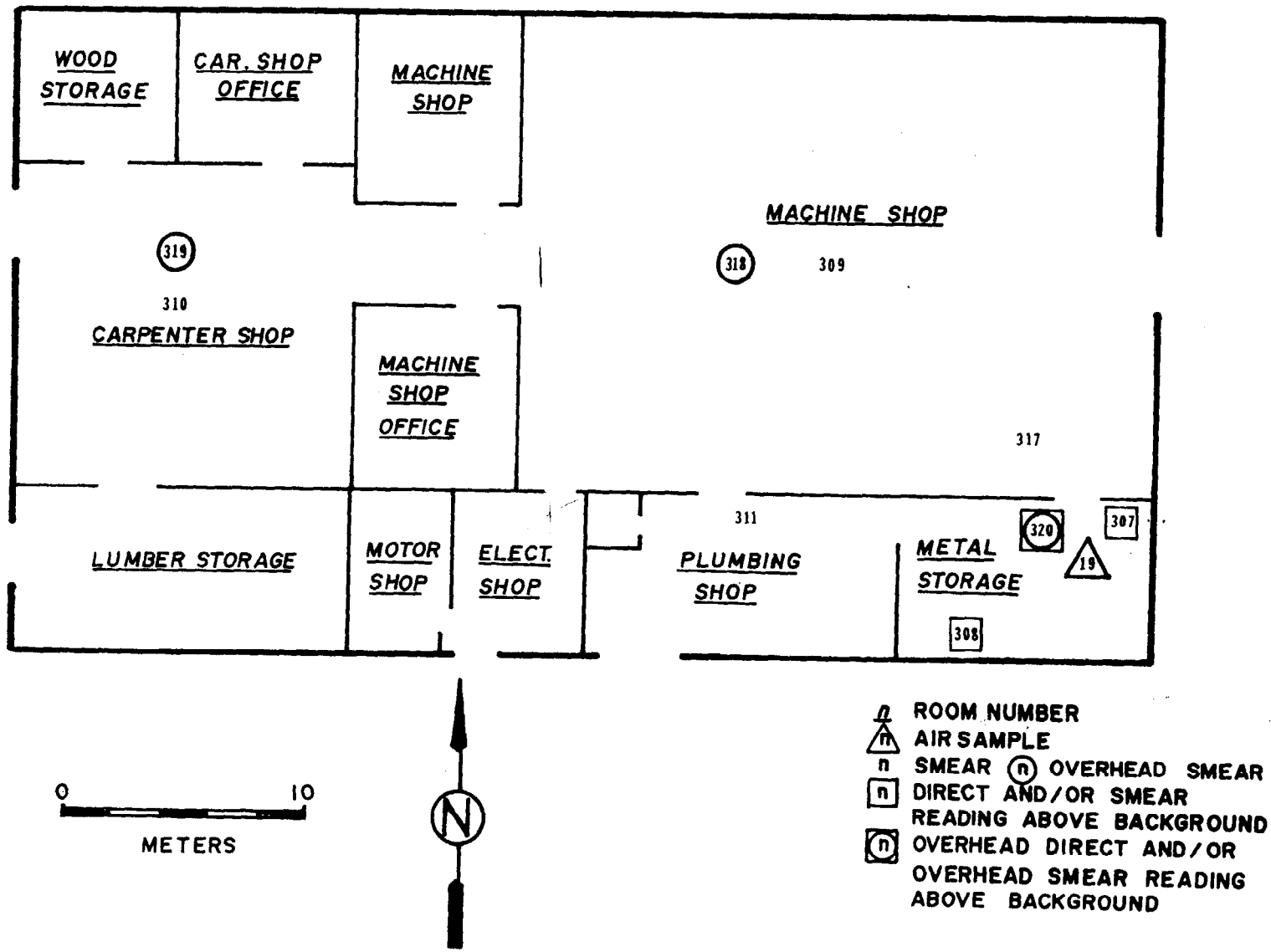


Fig. 14. Building 5

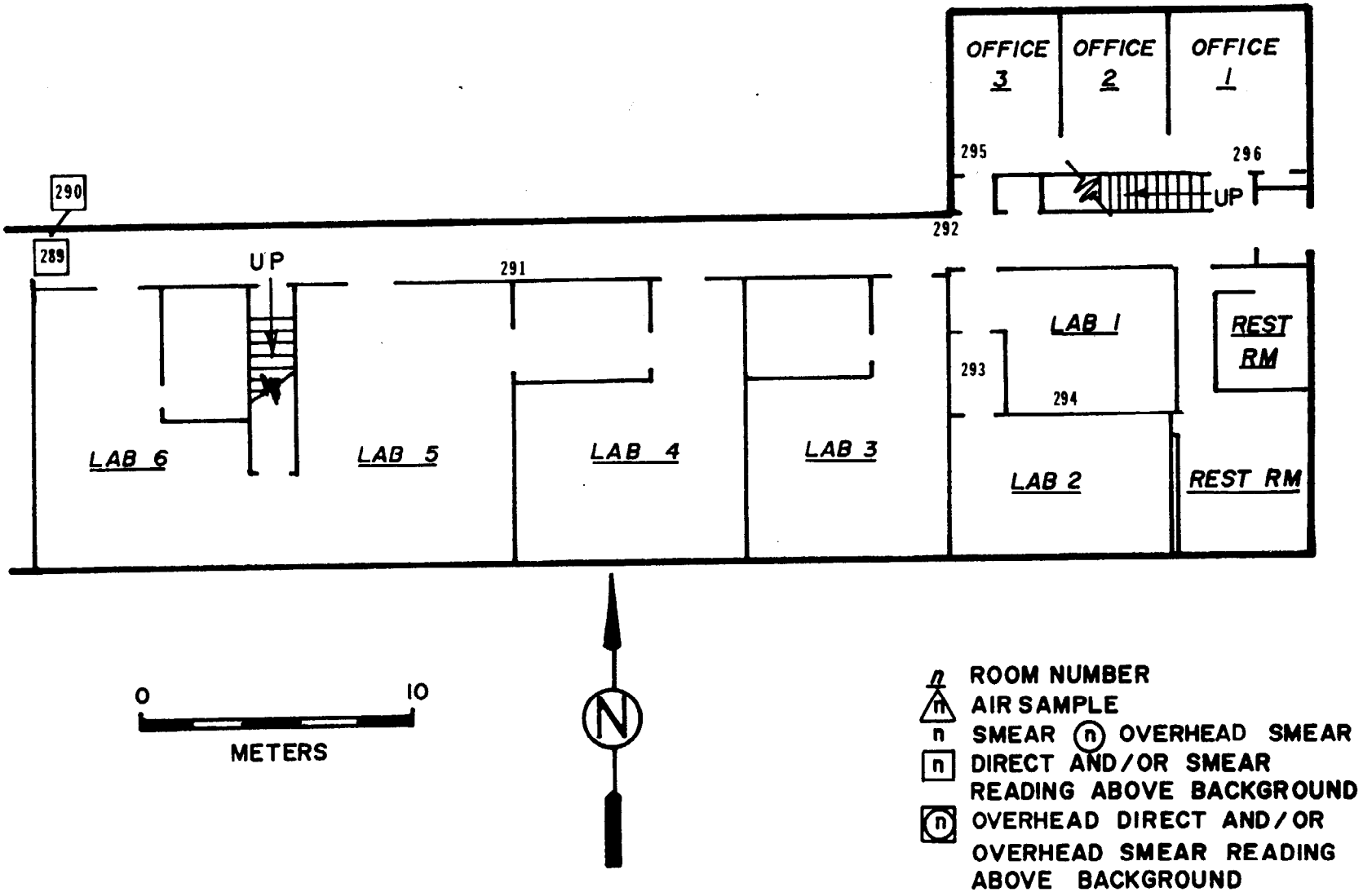


Fig. 15. Building 17

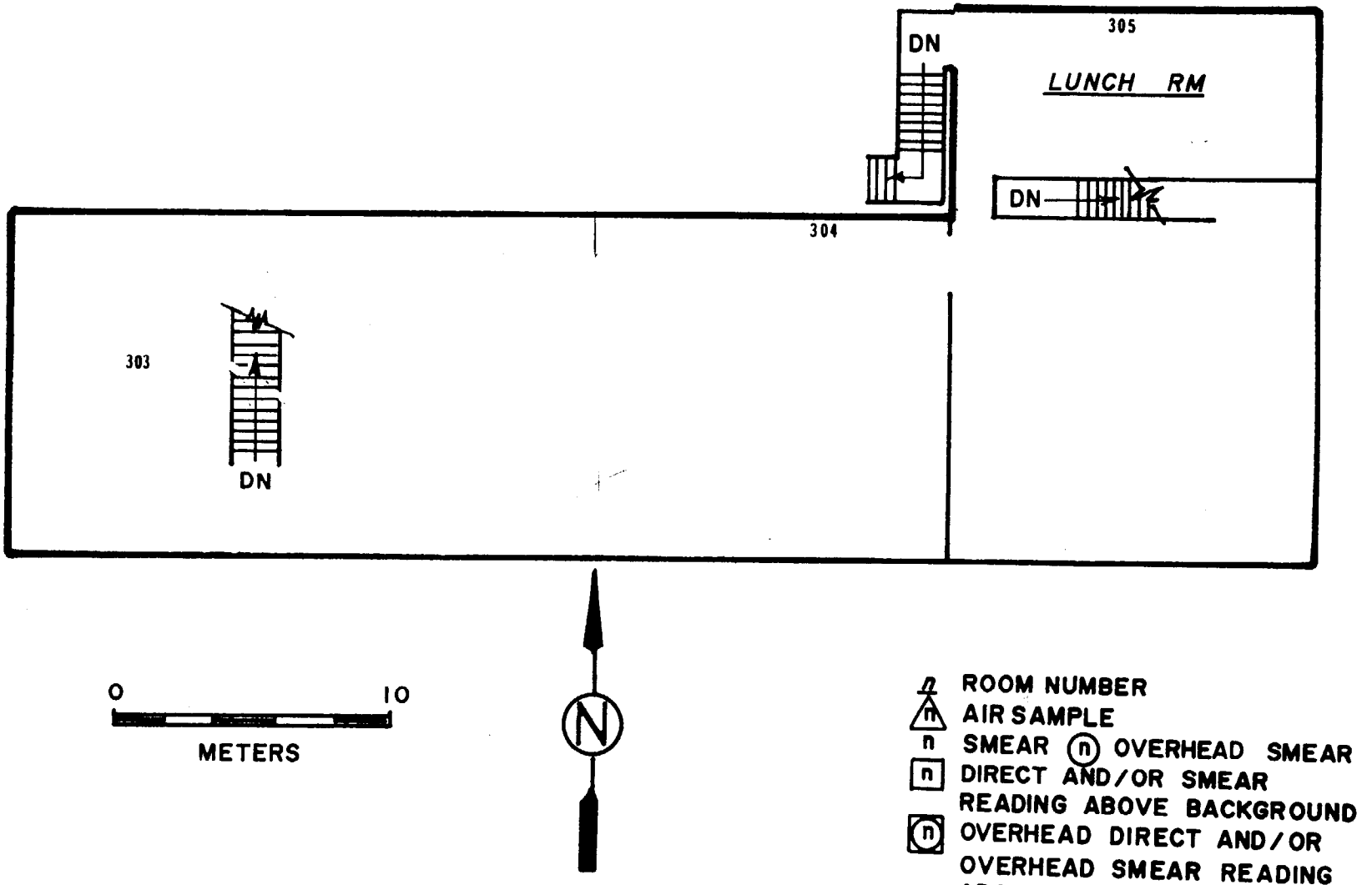


Fig. 16. Building 17

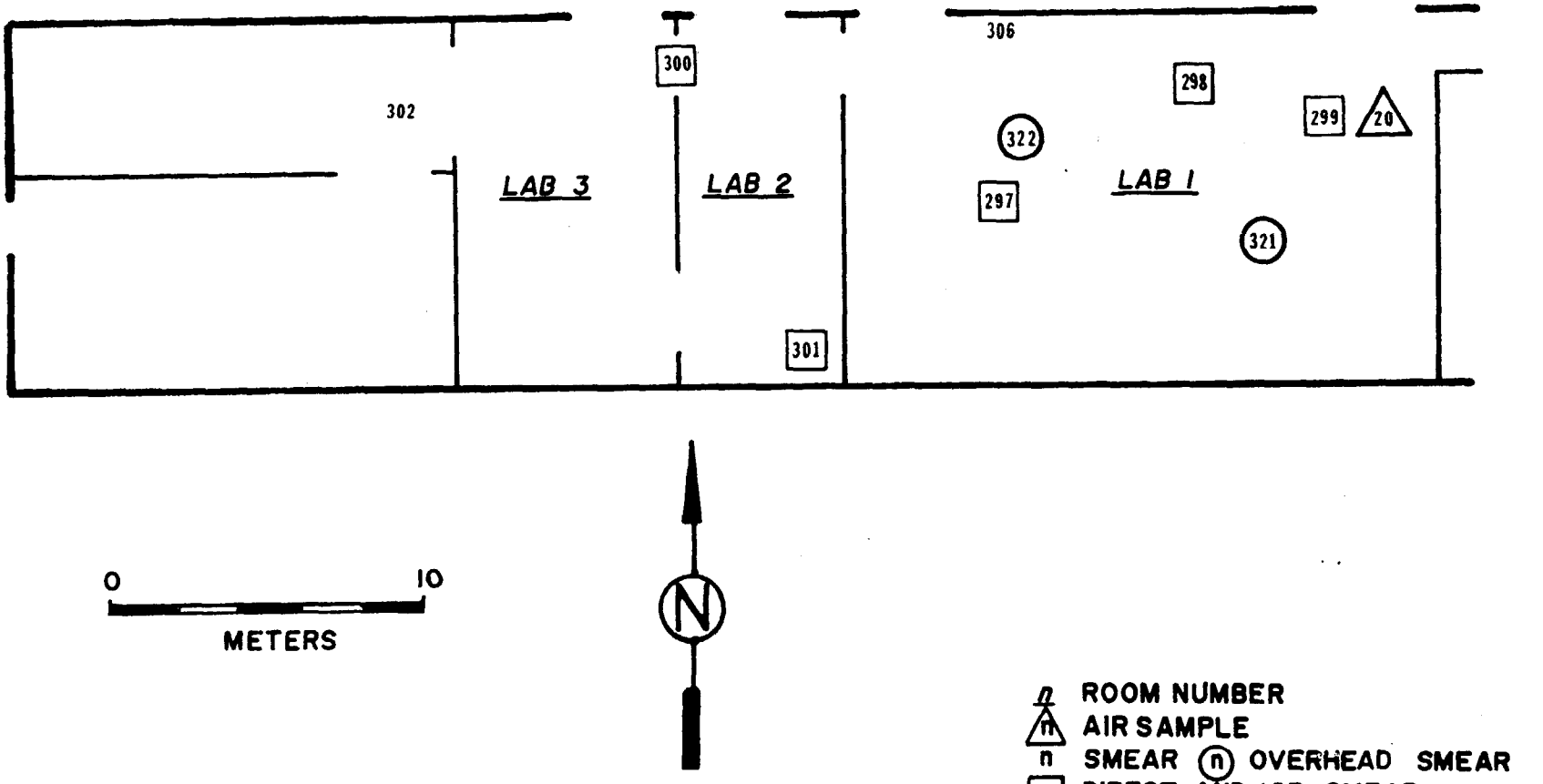


Fig. 17. Building 17

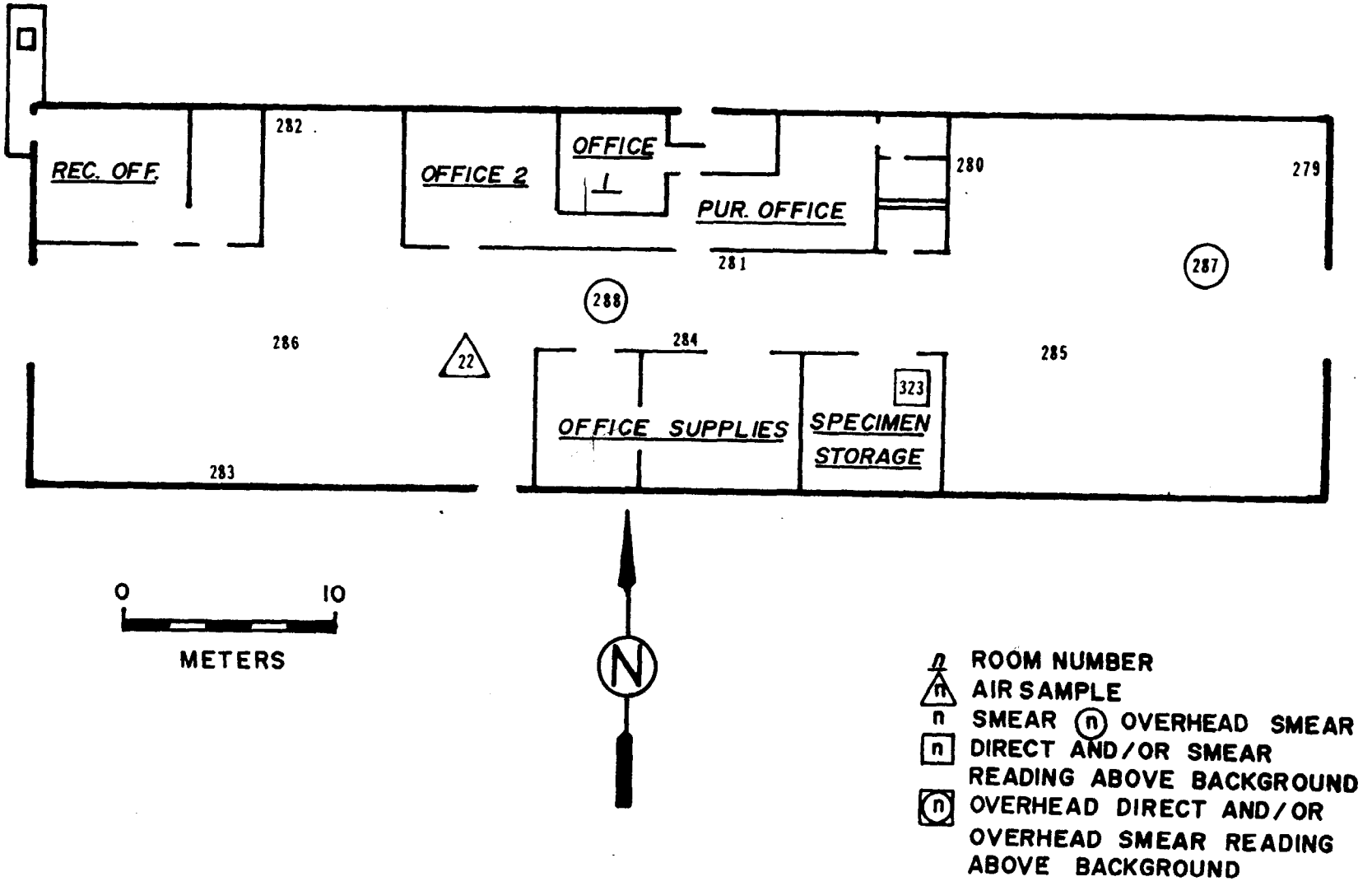


Fig. 18. Building 22

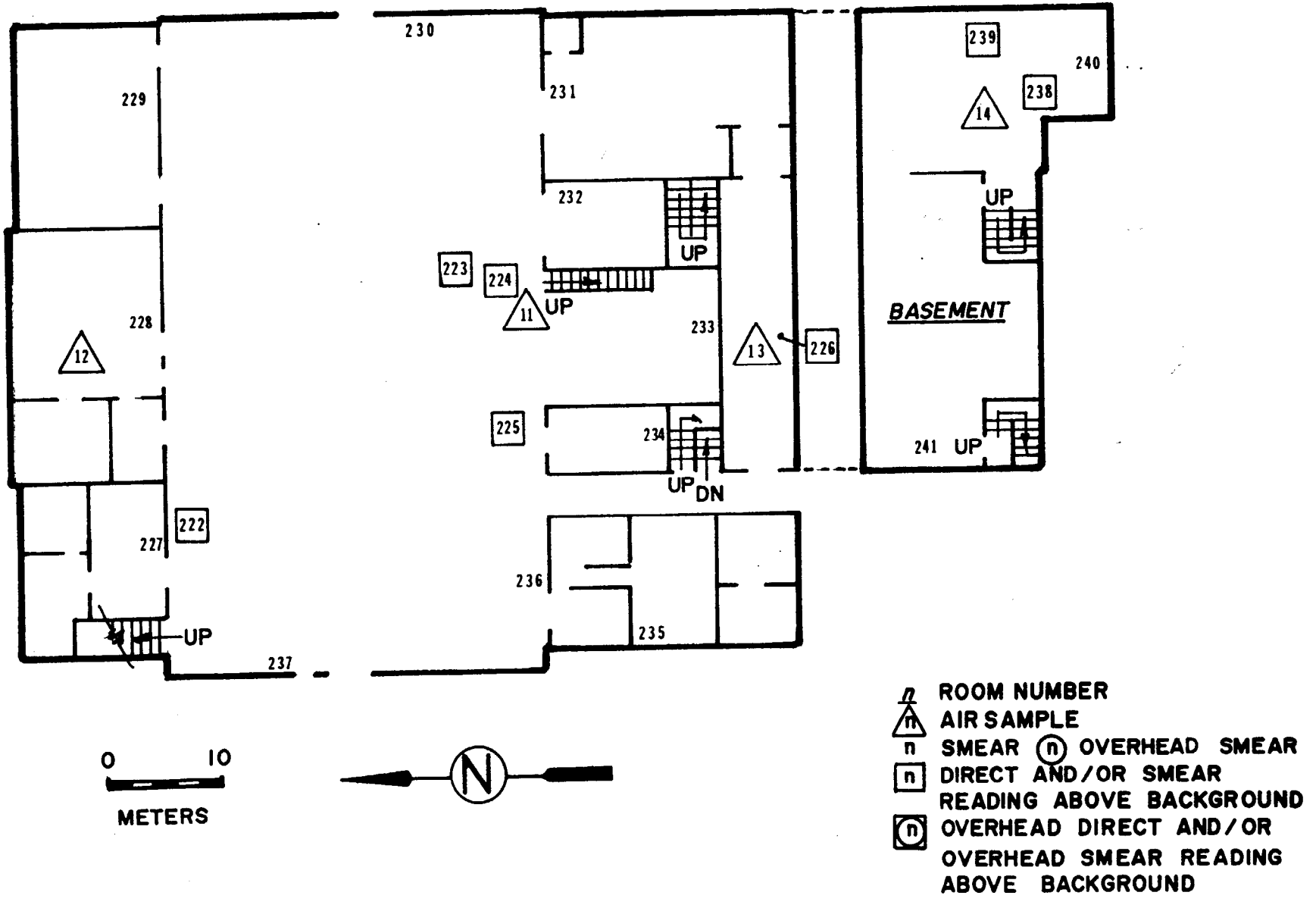


Fig. 19. Building 23

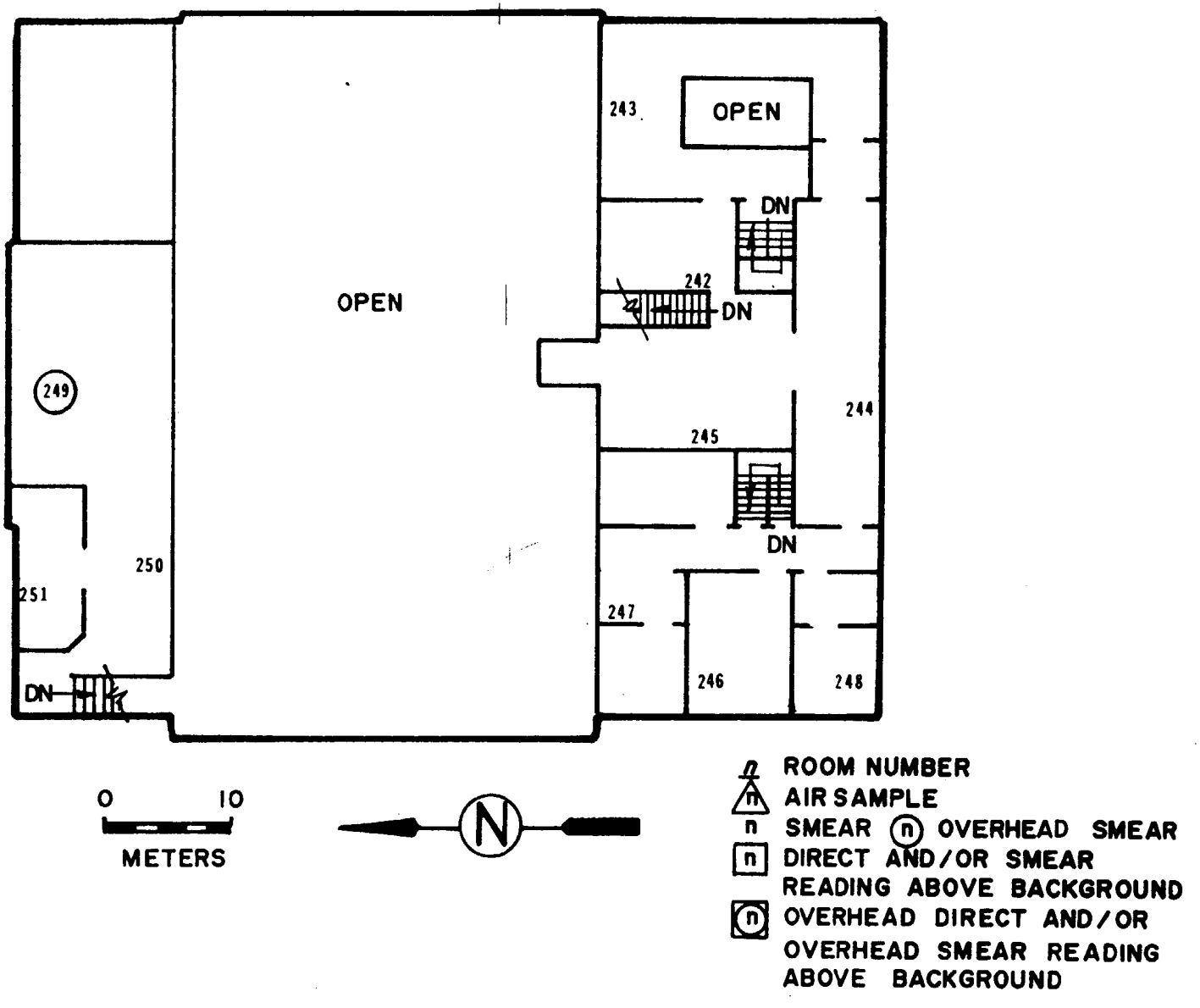
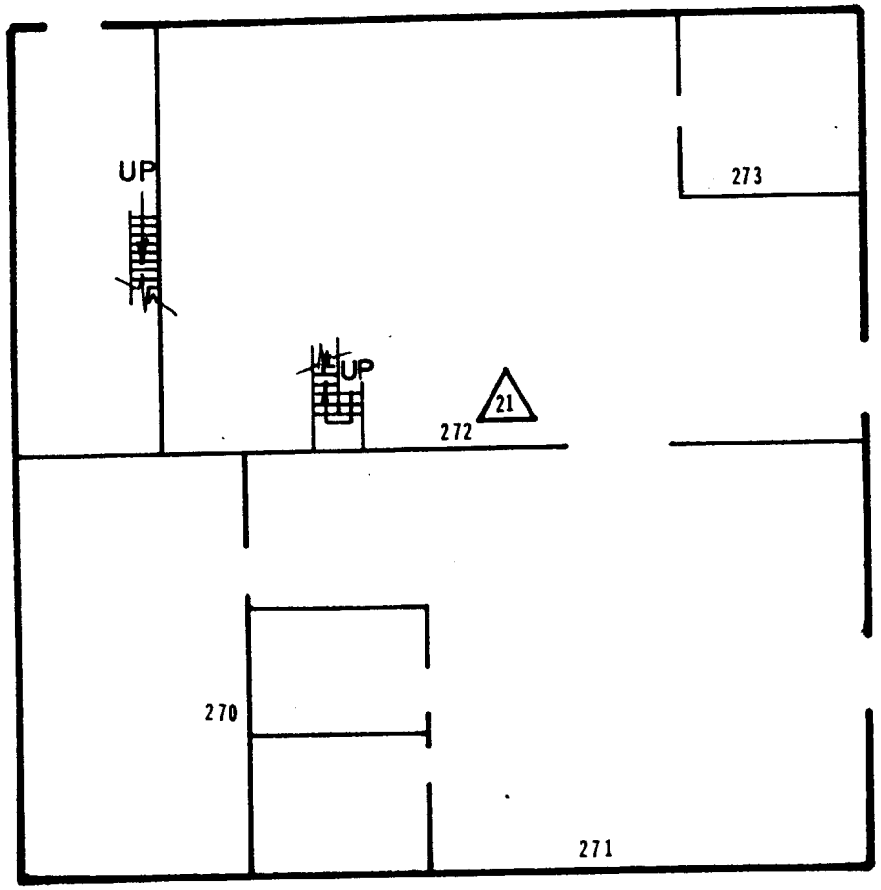
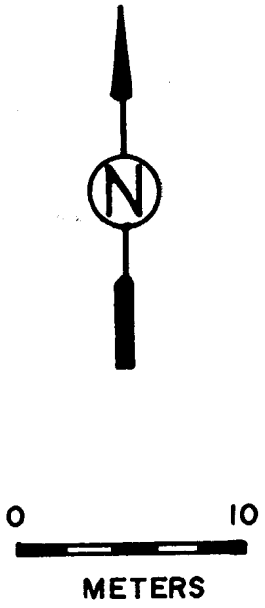


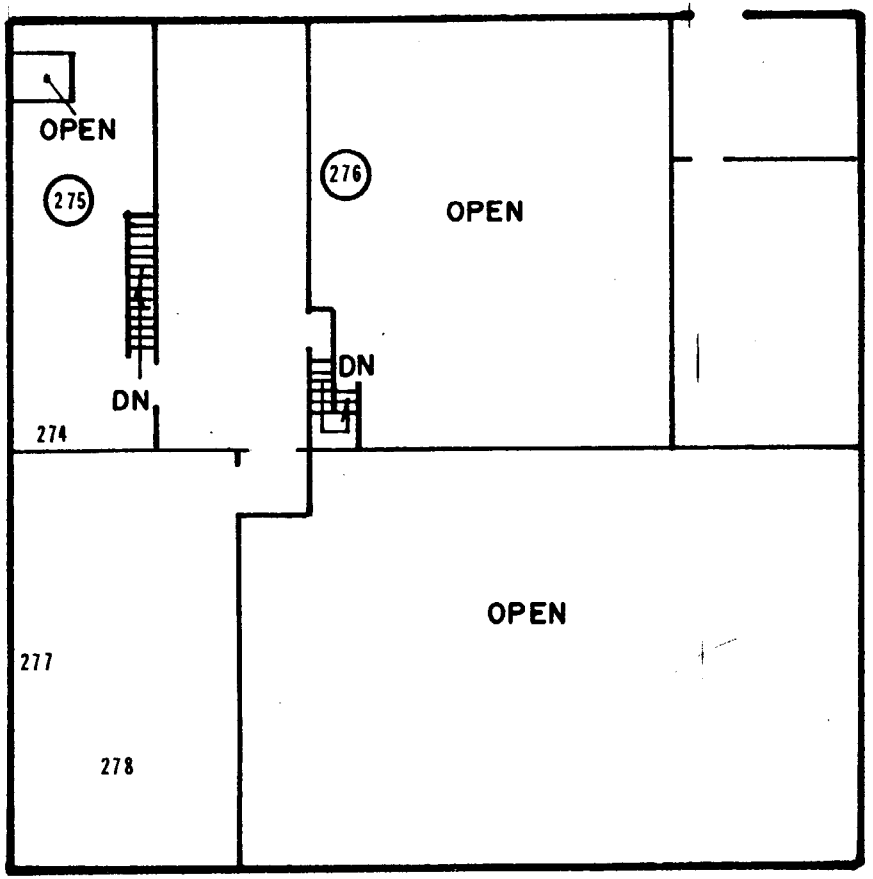
Fig. 20. Building 23, Second Floor

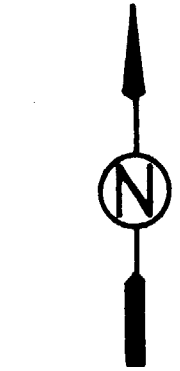




ROOM NUMBER
AIR SAMPLE
SMEAR (n) OVERHEAD SMEAR
DIRECT AND/OR SMEAR READING ABOVE BACKGROUND
OVERHEAD DIRECT AND/OR OVERHEAD SMEAR READING ABOVE BACKGROUND

Fig. 21. Building 24





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(n) OVERHEAD DIRECT AND/OR OVERHEAD SMEAR READING ABOVE BACKGROUND

Fig. 22. Building 24

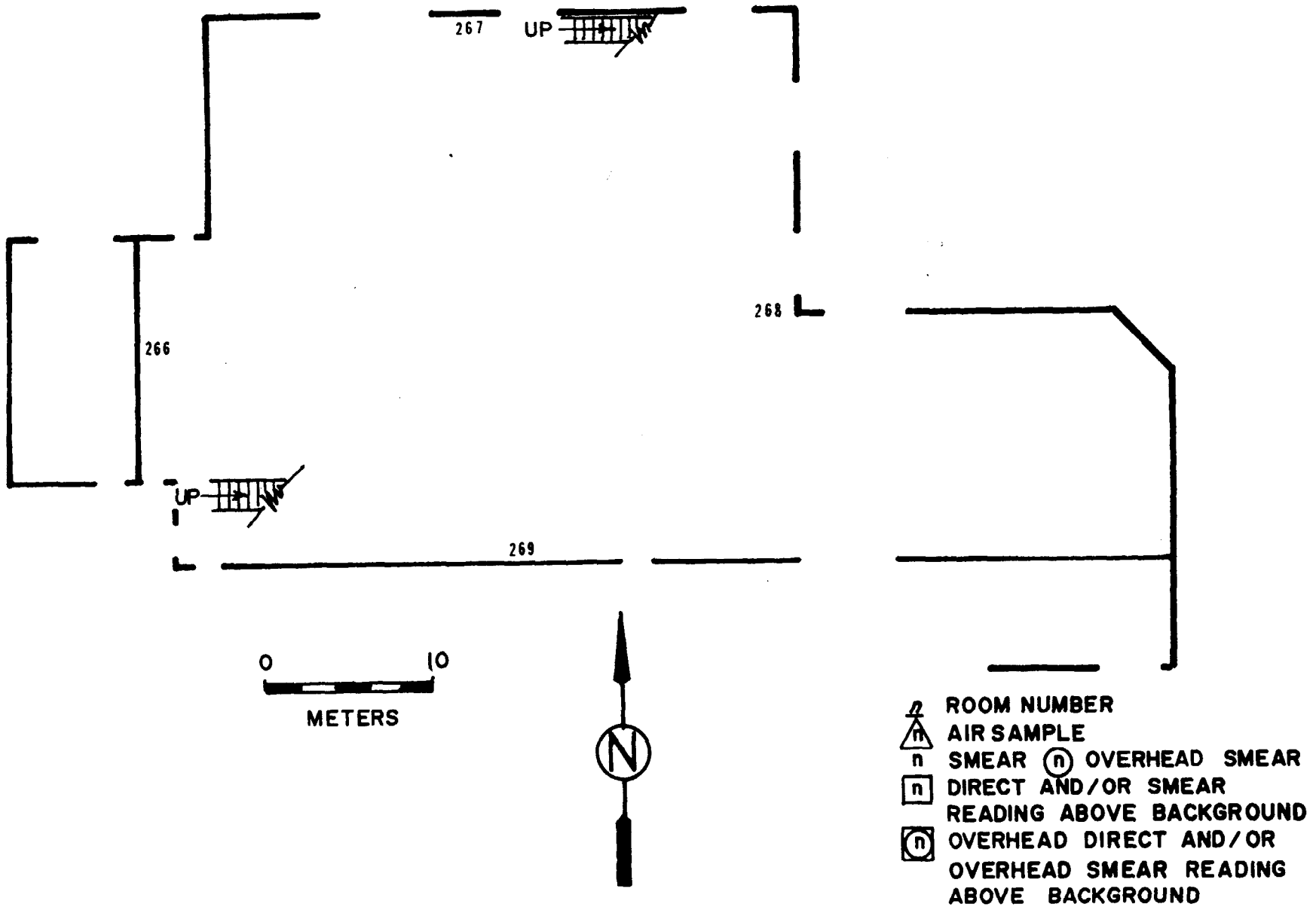

Fig. 23. Building 25

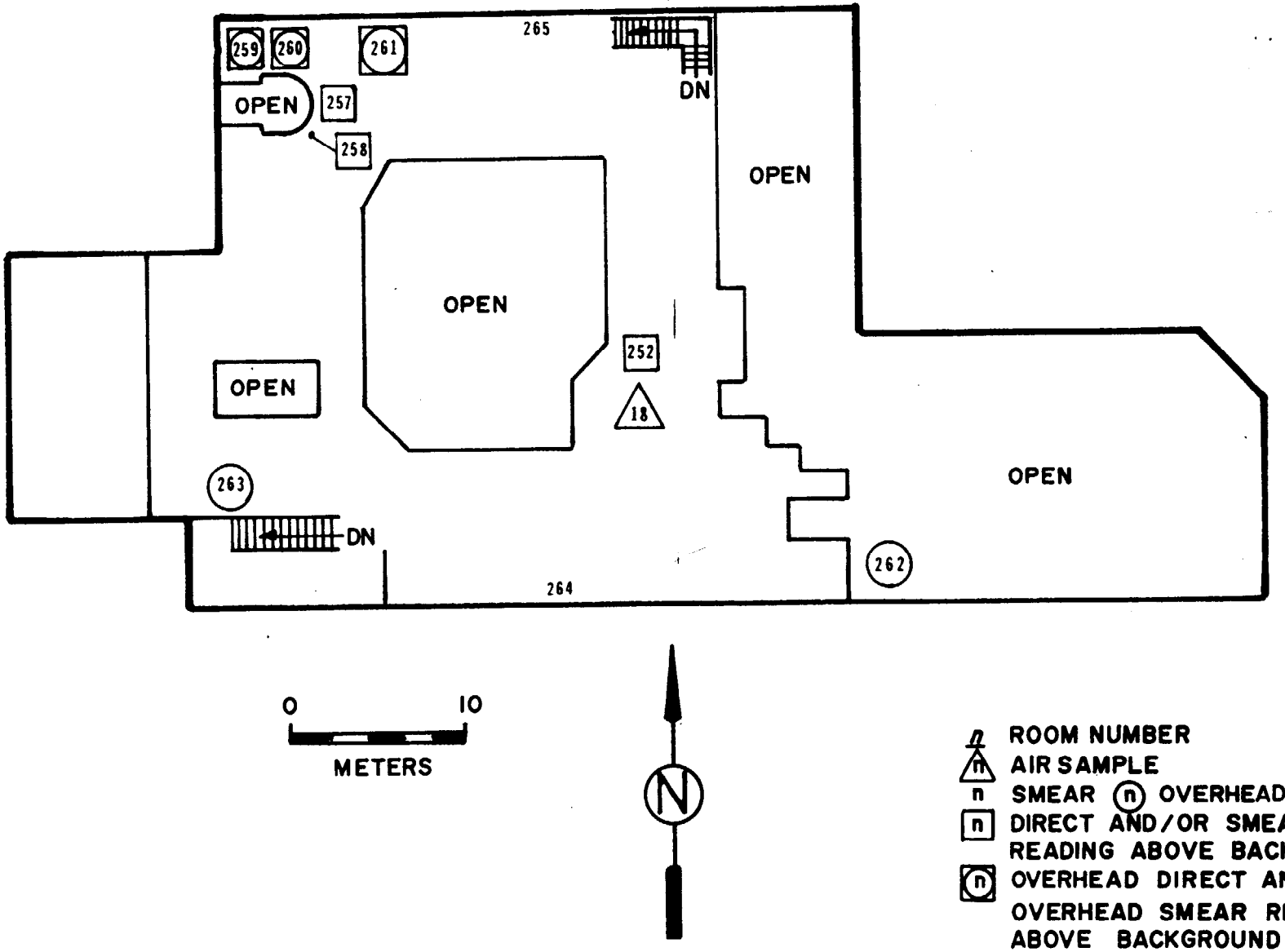

Fig. 24. Building 25, Second Floor

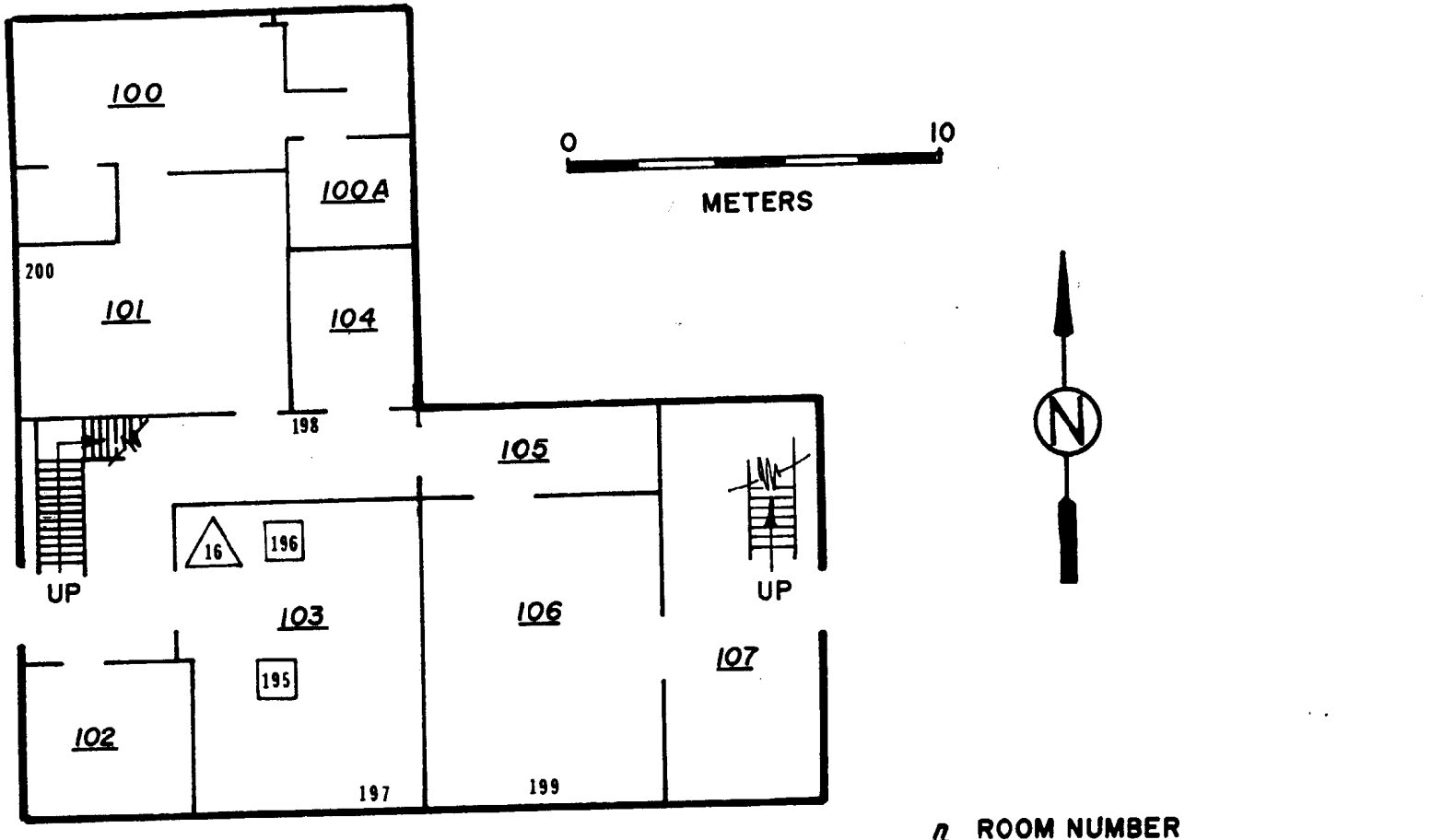

Fig. 25. Building 26

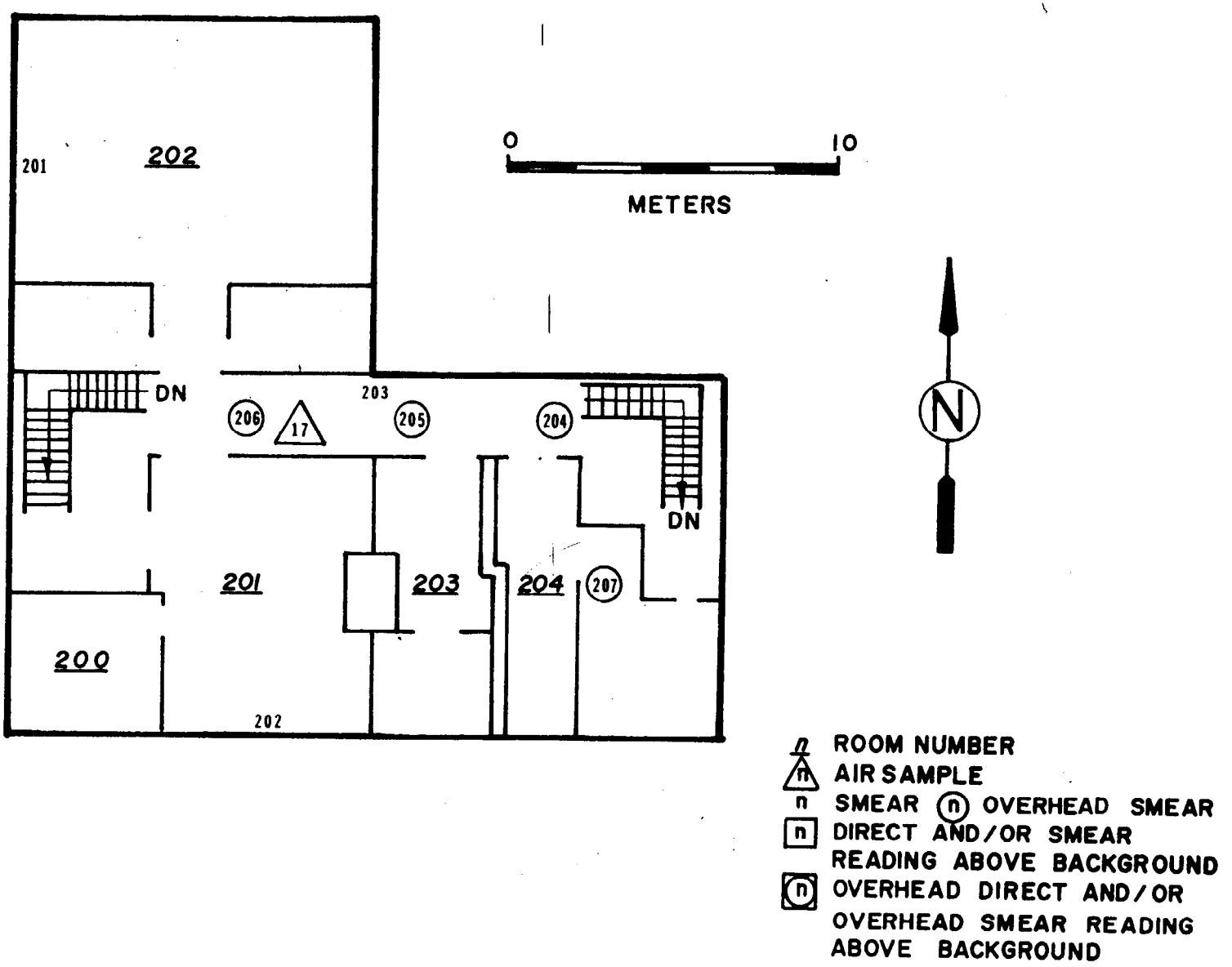

Fig. 26. Building 26, Second Floor.

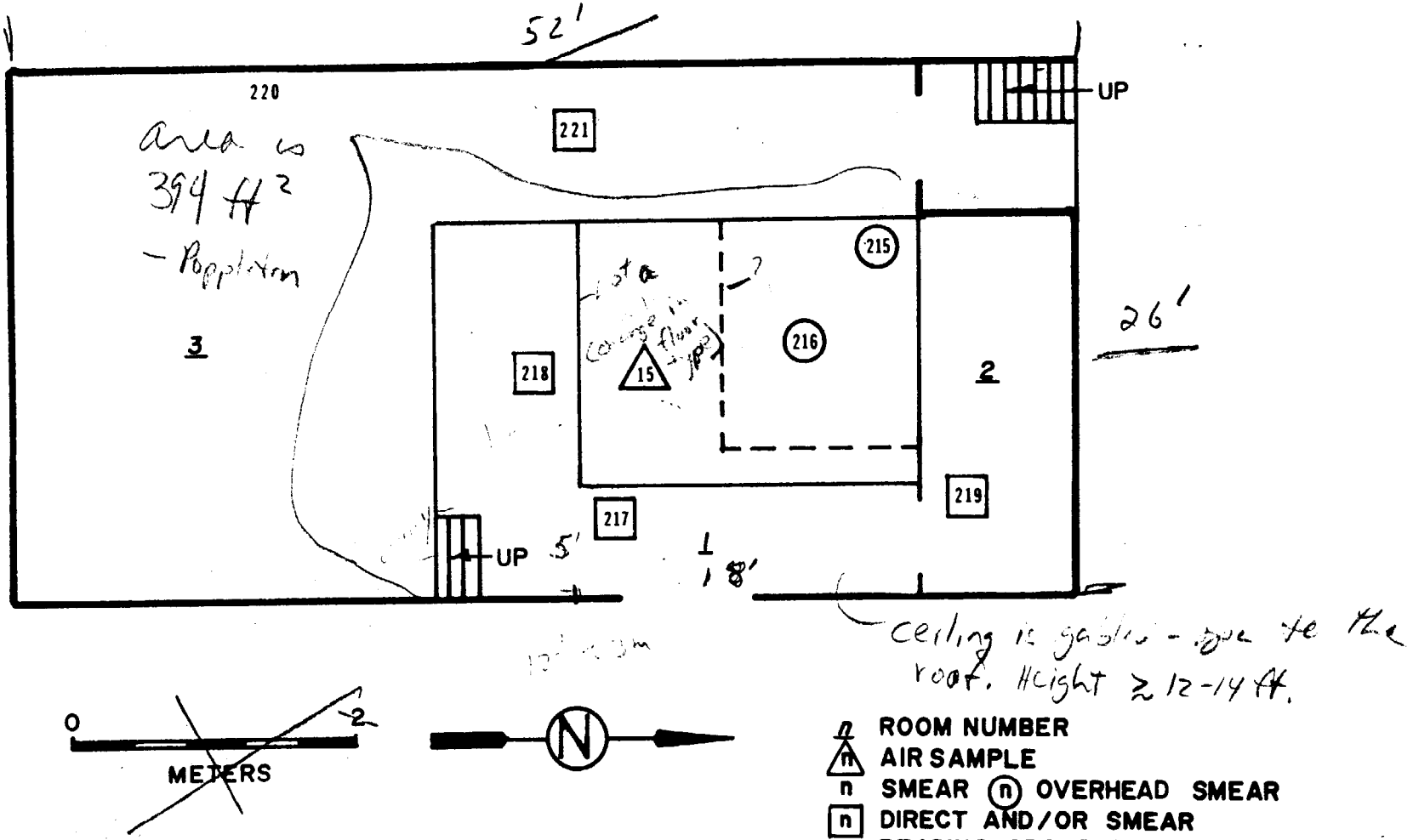

Fig. 27. Building 27

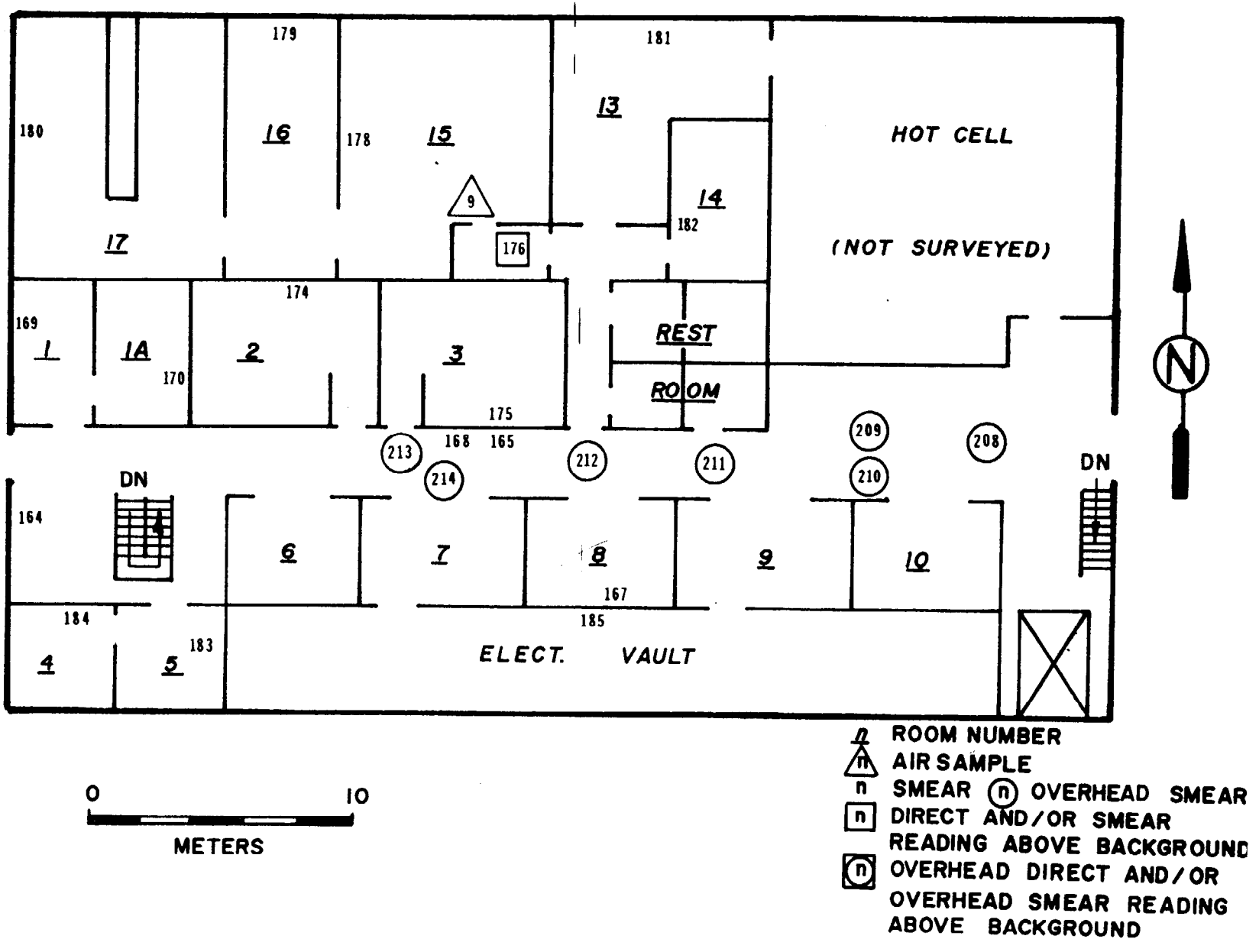

Fig. 28. Building 28

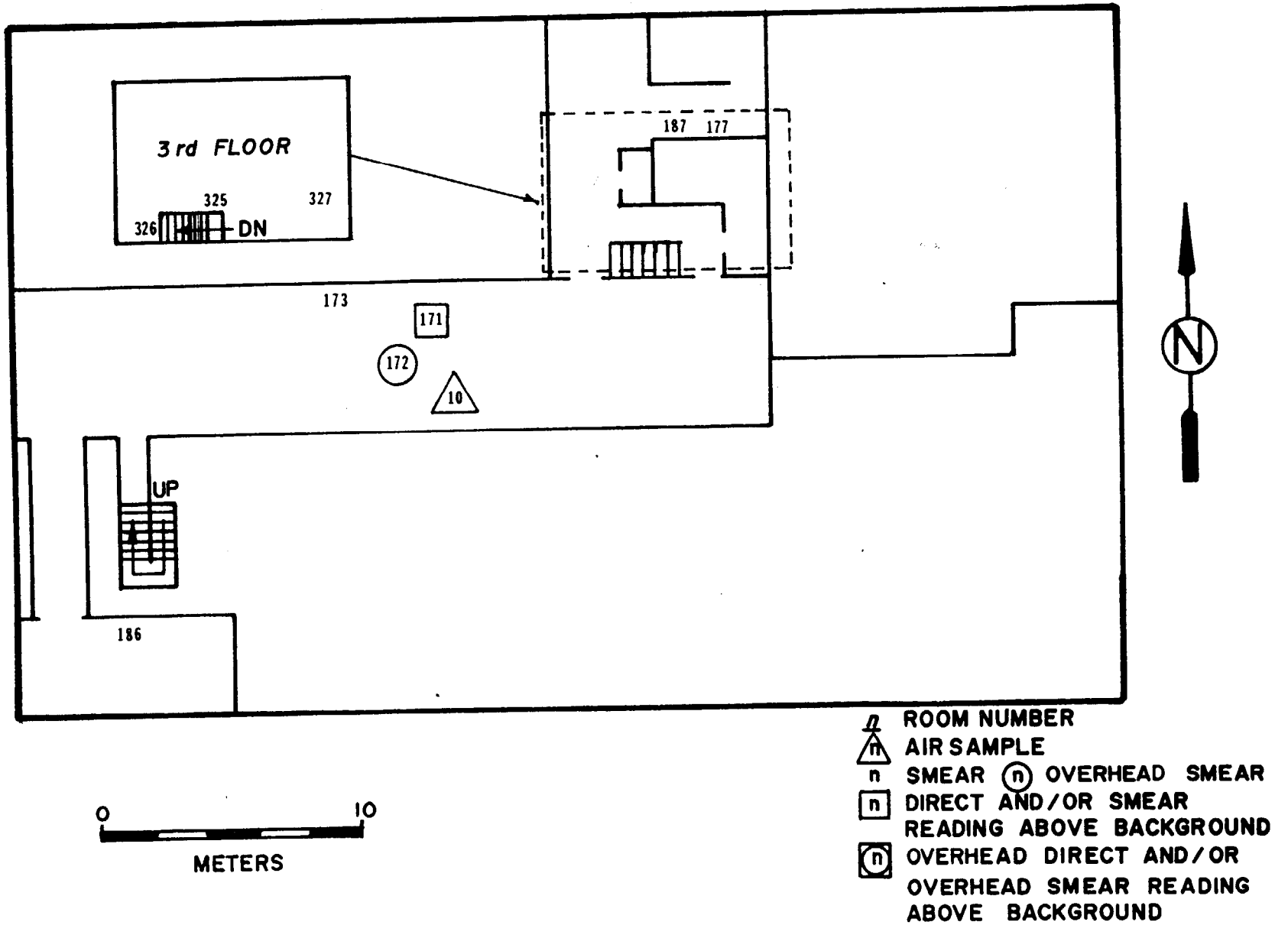

Fig. 29. Building 28, Second Floor

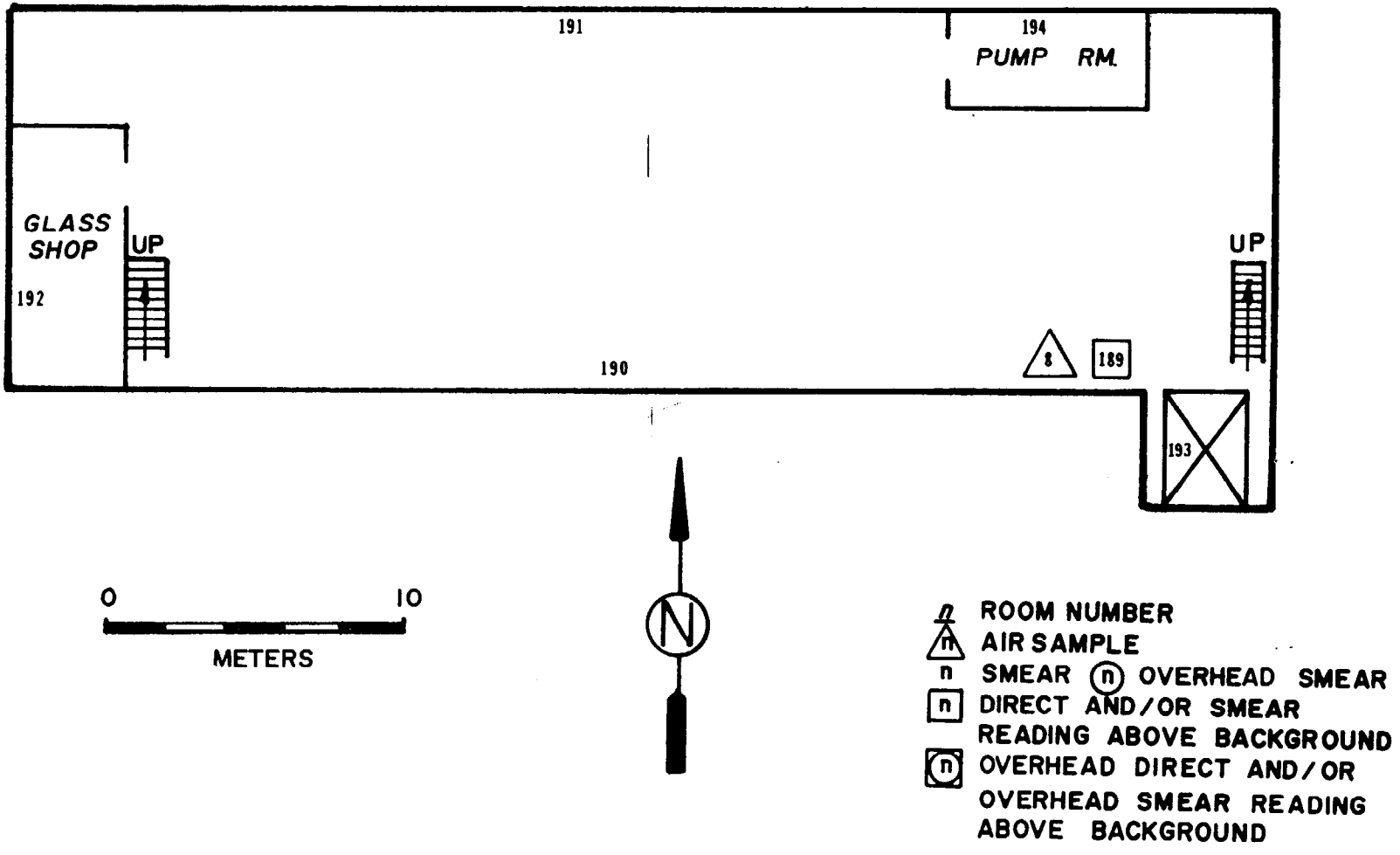

Fig. 30. Building 28, Basement

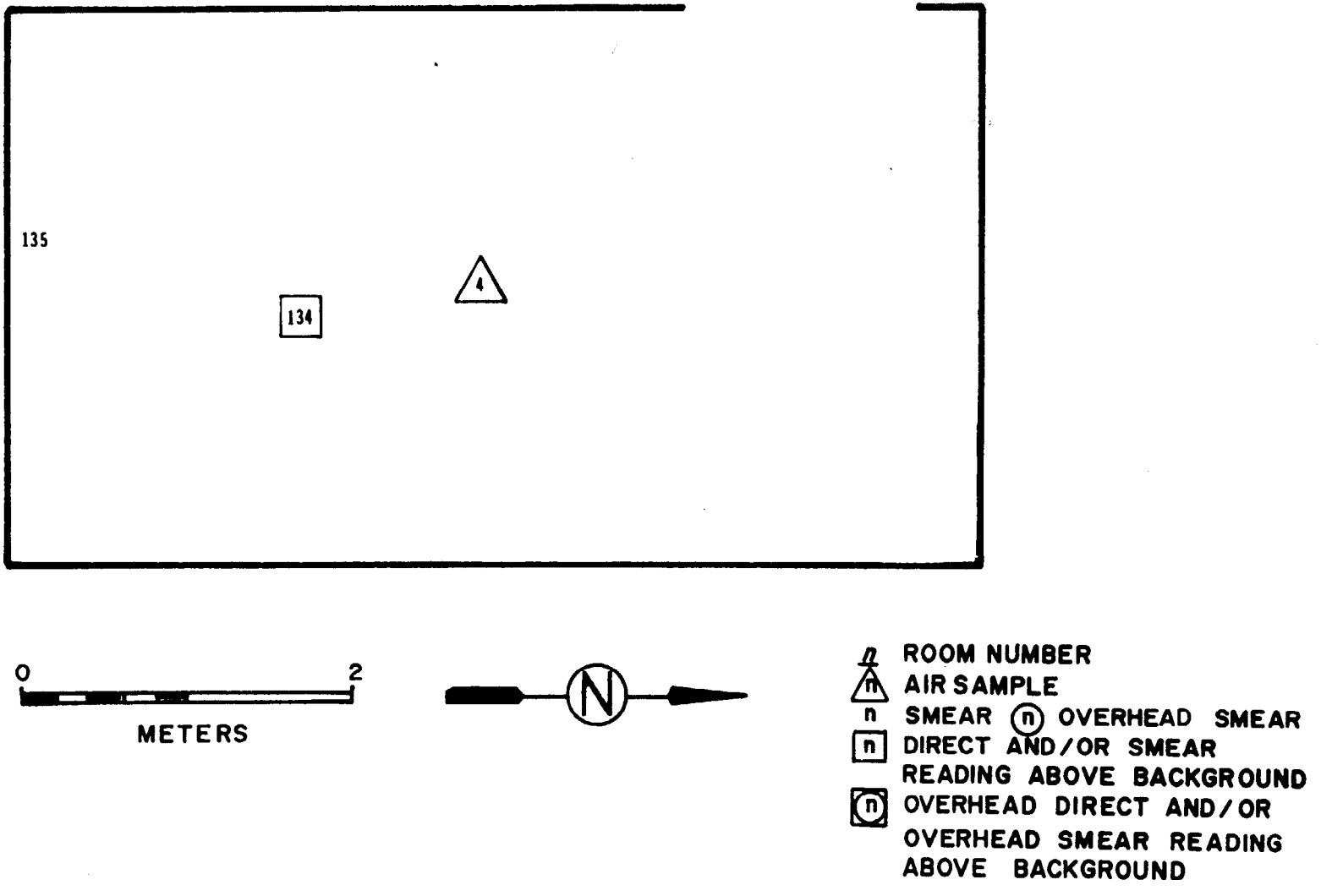

Fig. 31. Building 30, Room 8

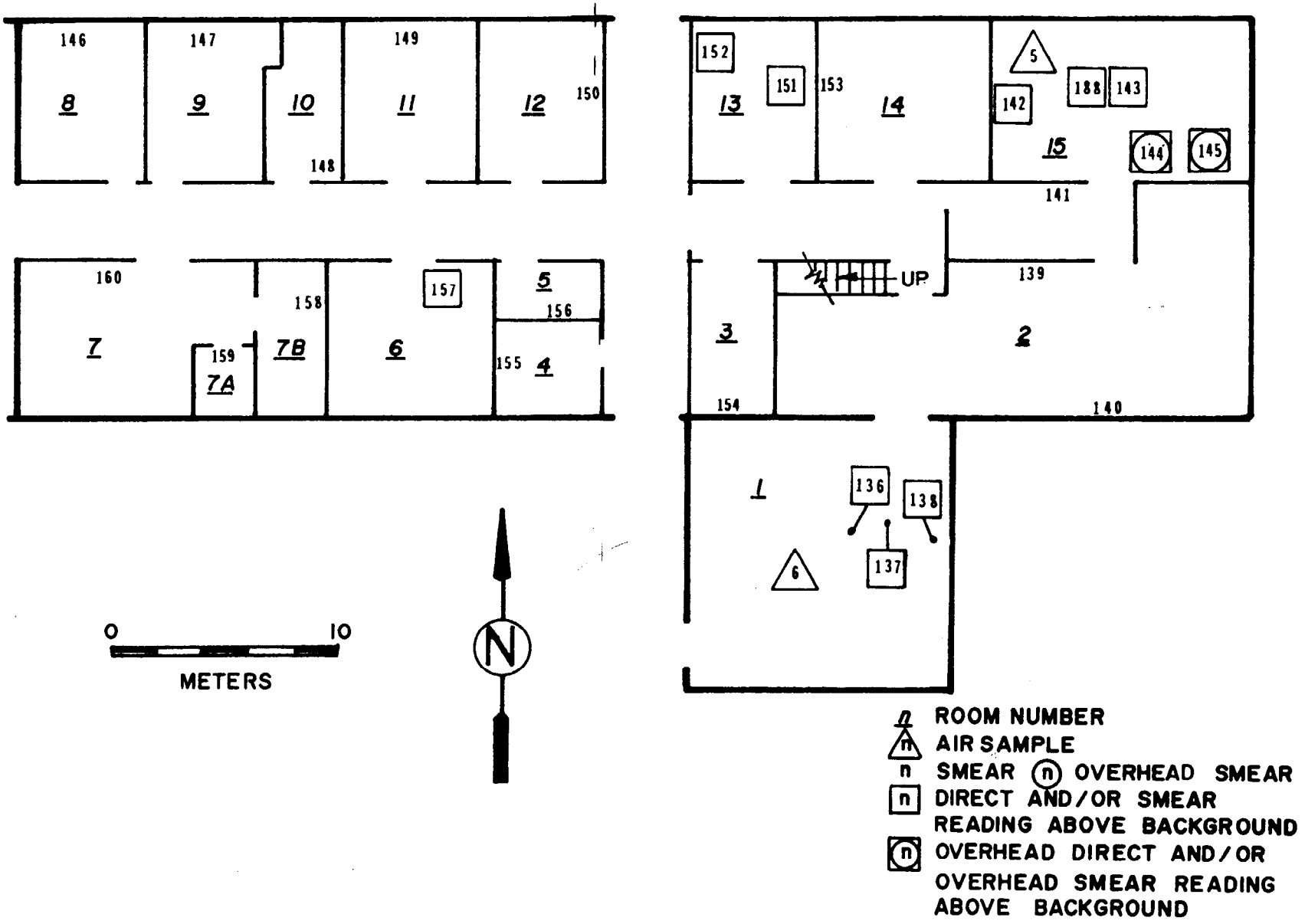

Fig. 32. Building 31

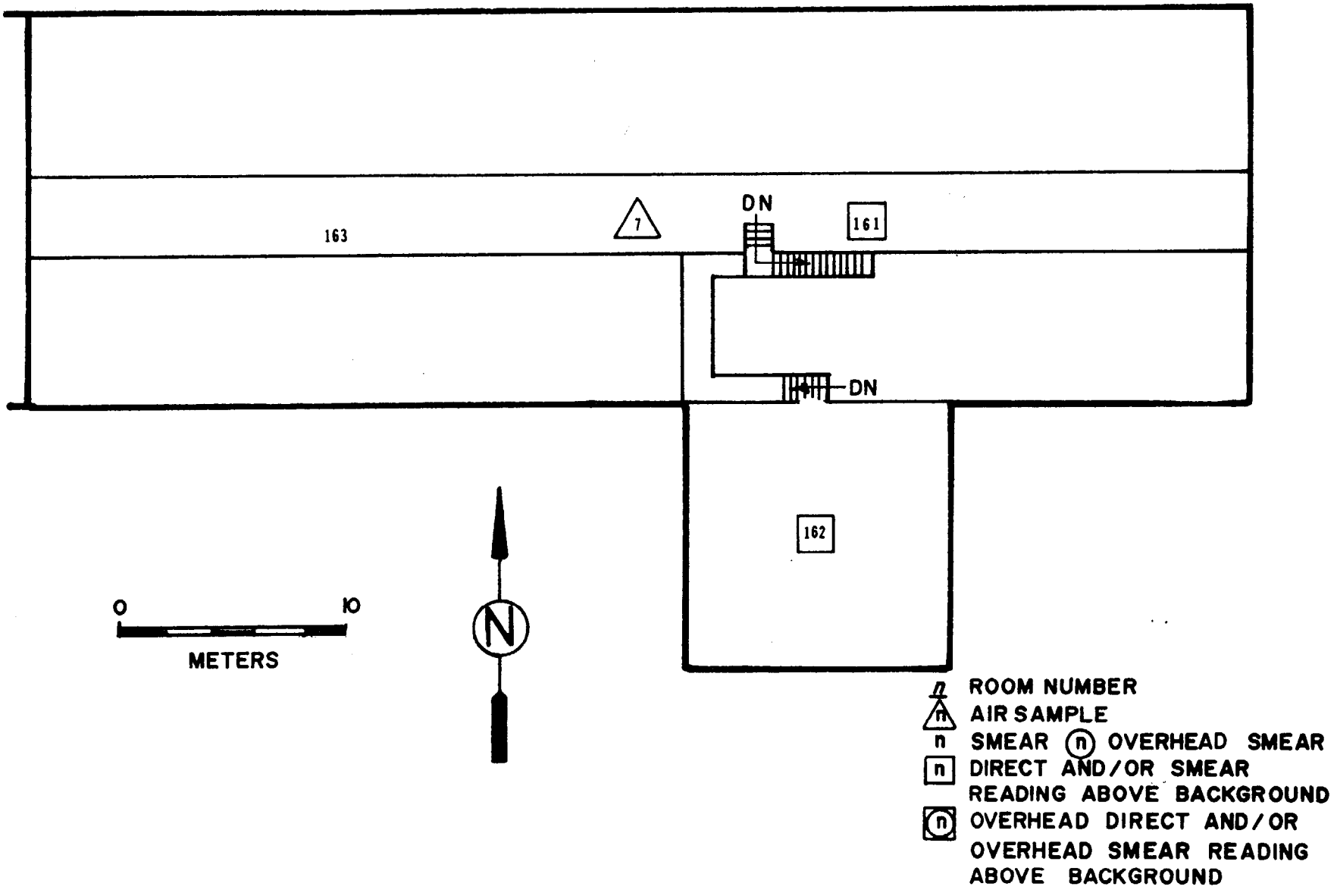

Fig. 33. Building 31, Second Floor

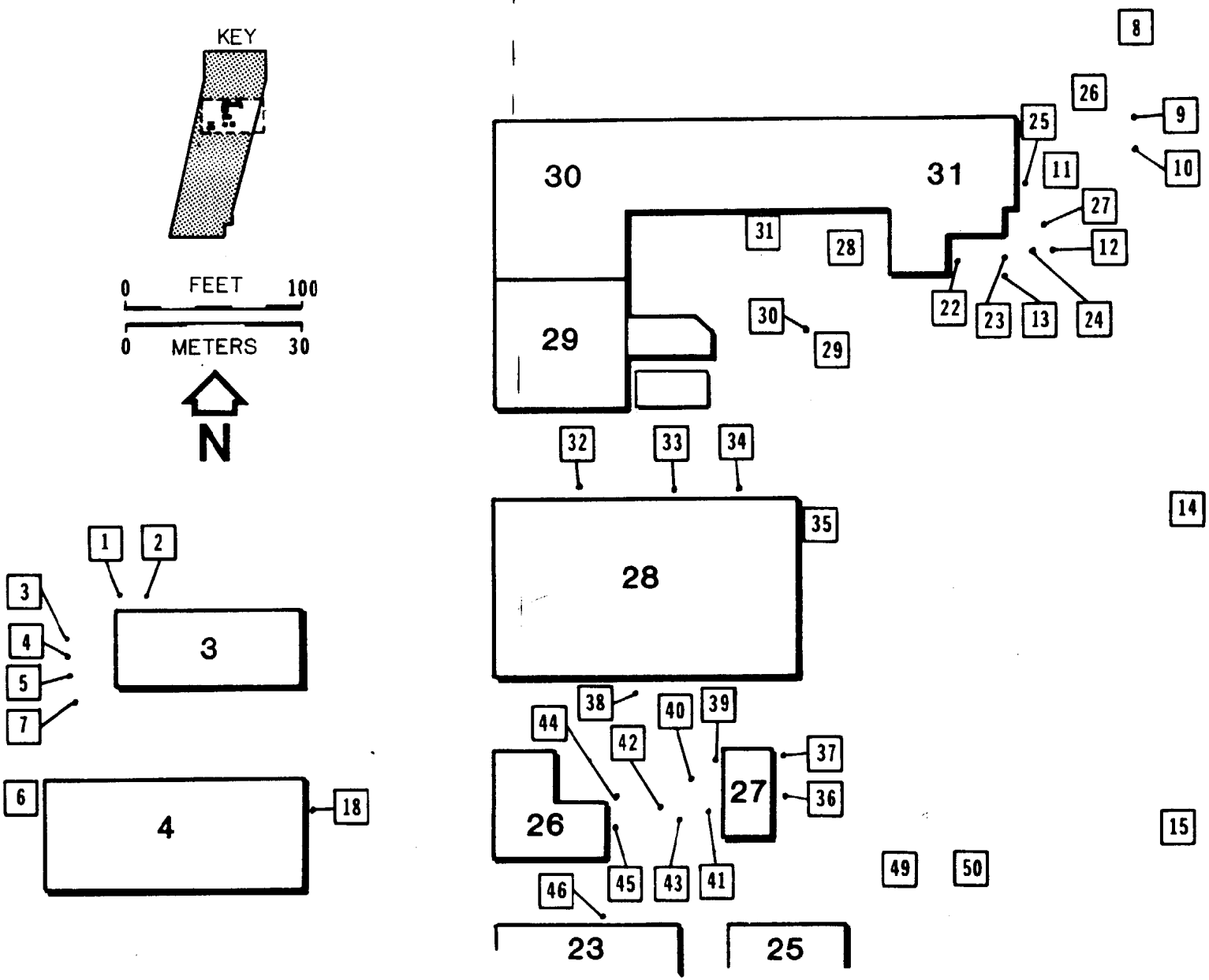

Fig. 34. Exterior Contamination - North

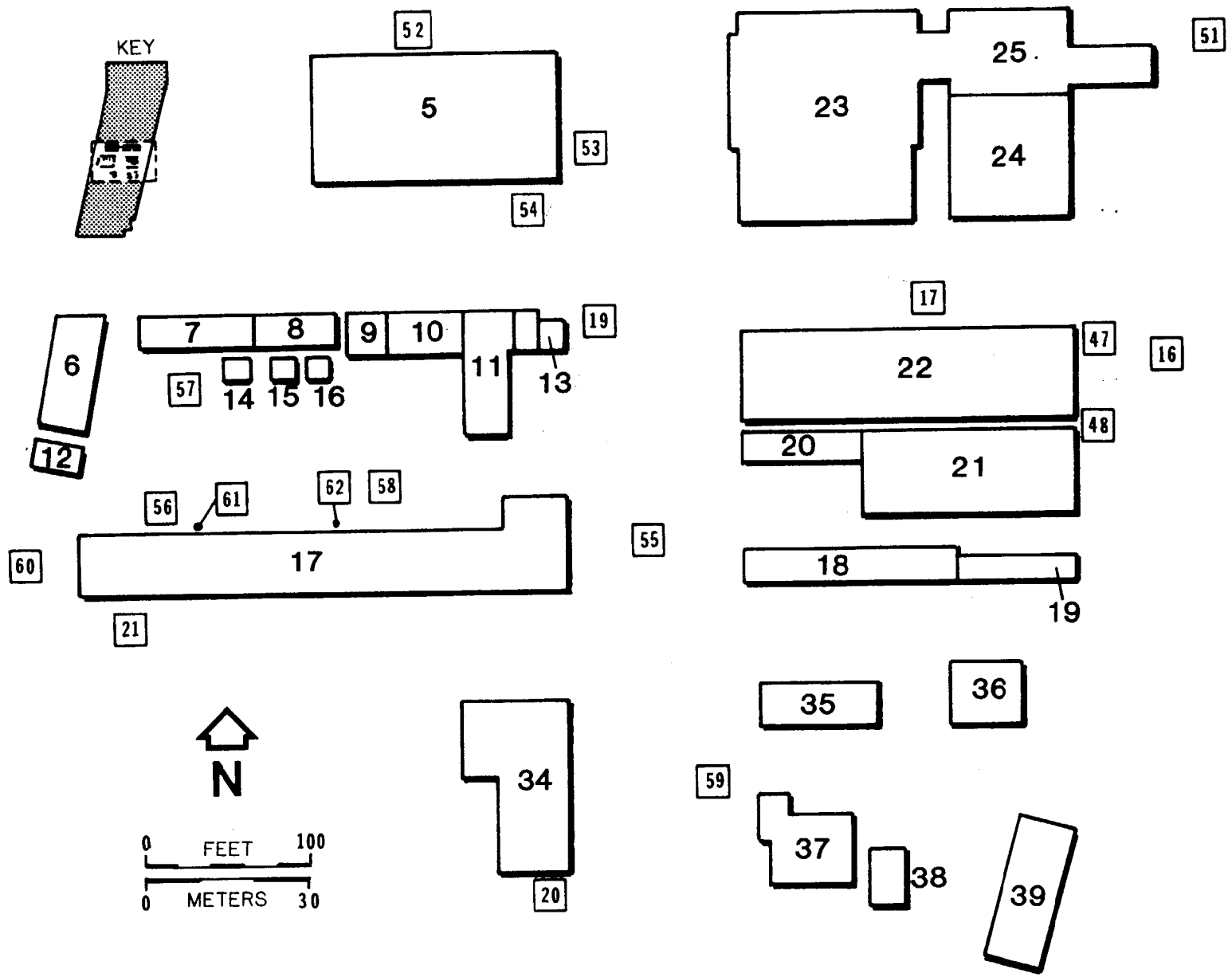

Fig. 35. Exterior Contamination - South

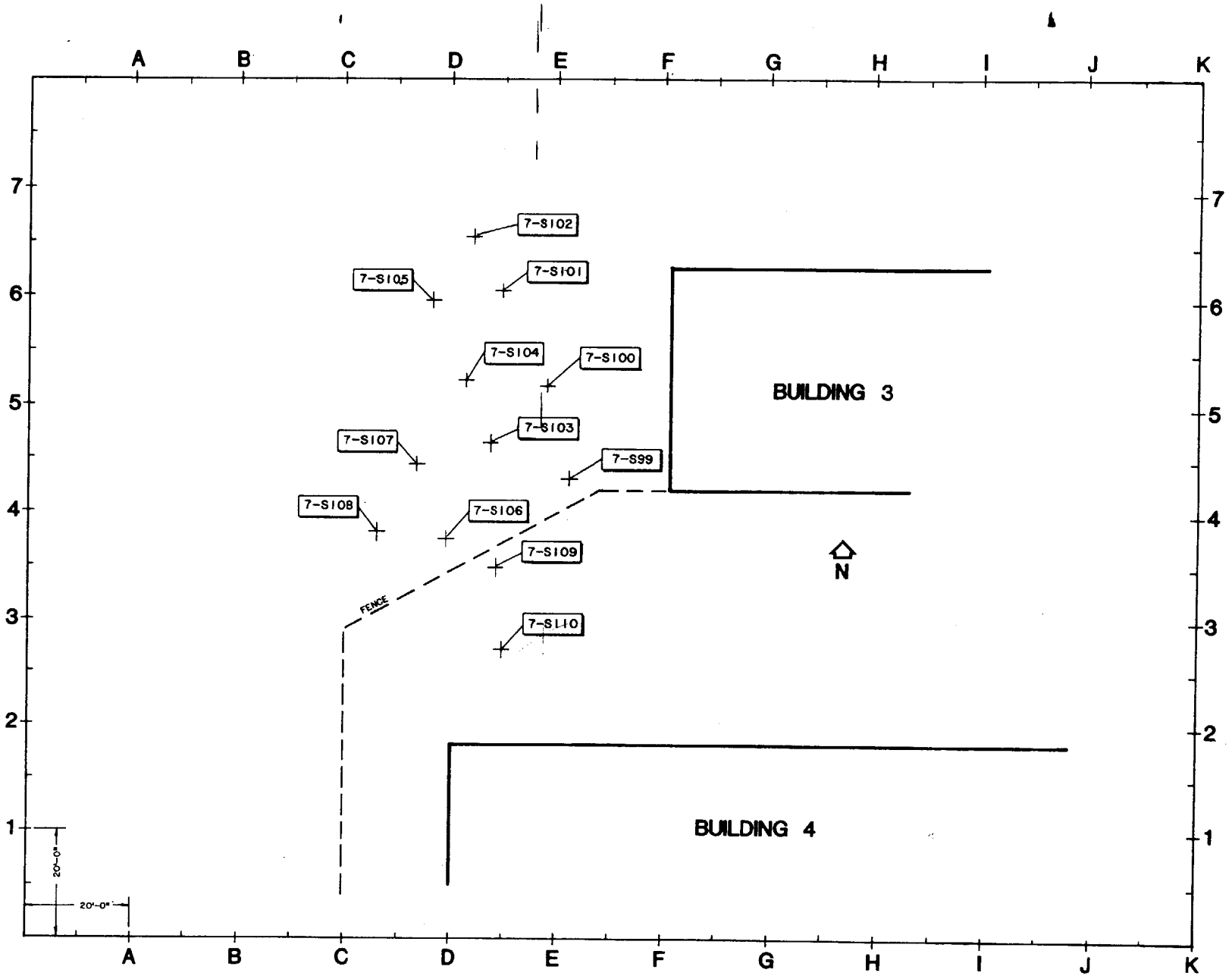

Fig. 36. Working Drawing for Bore Hole Locations

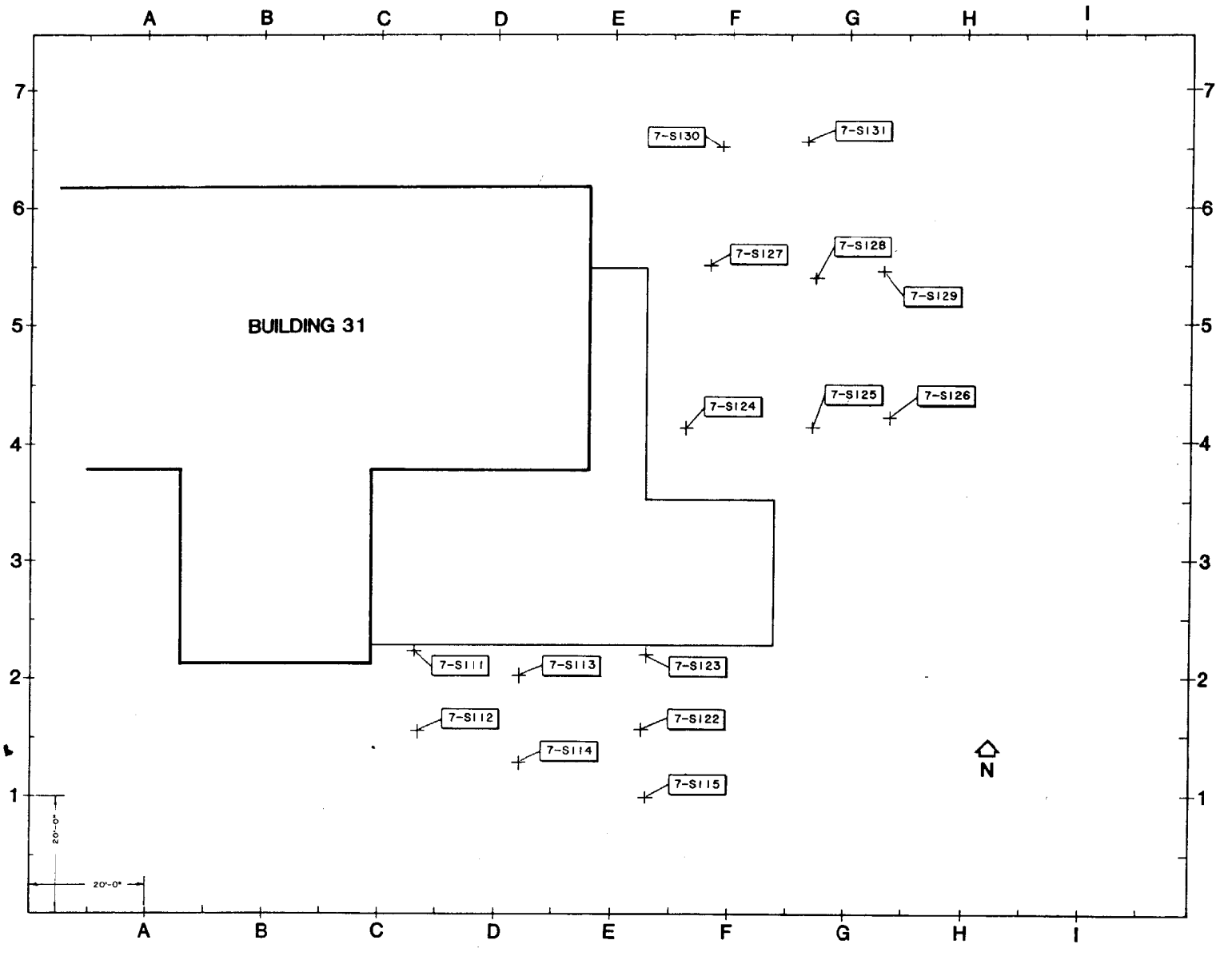

Fig. 37. Working Drawing for Bore Hole Locations

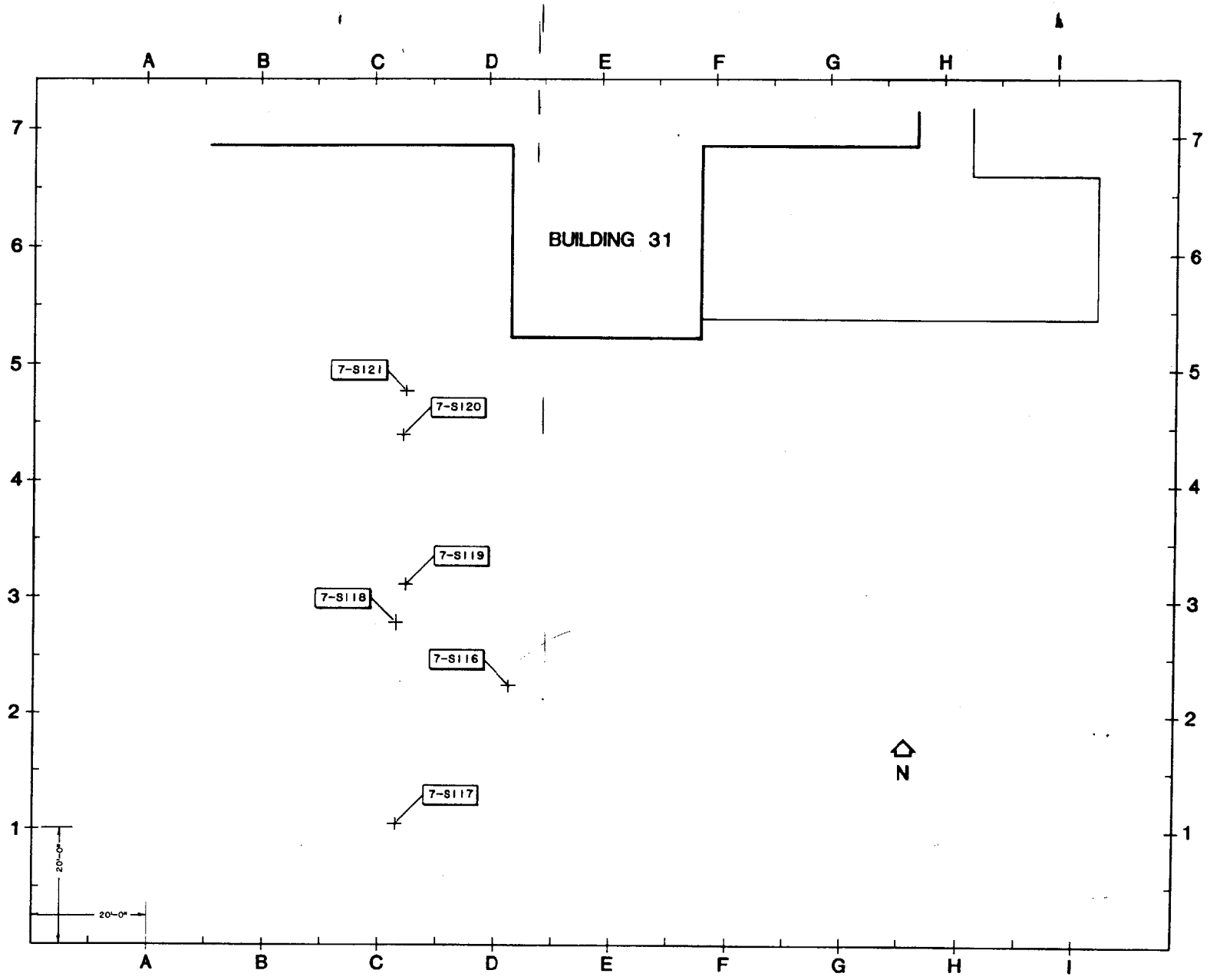

Fig. 38. Working Drawing for Bore Hole Locations

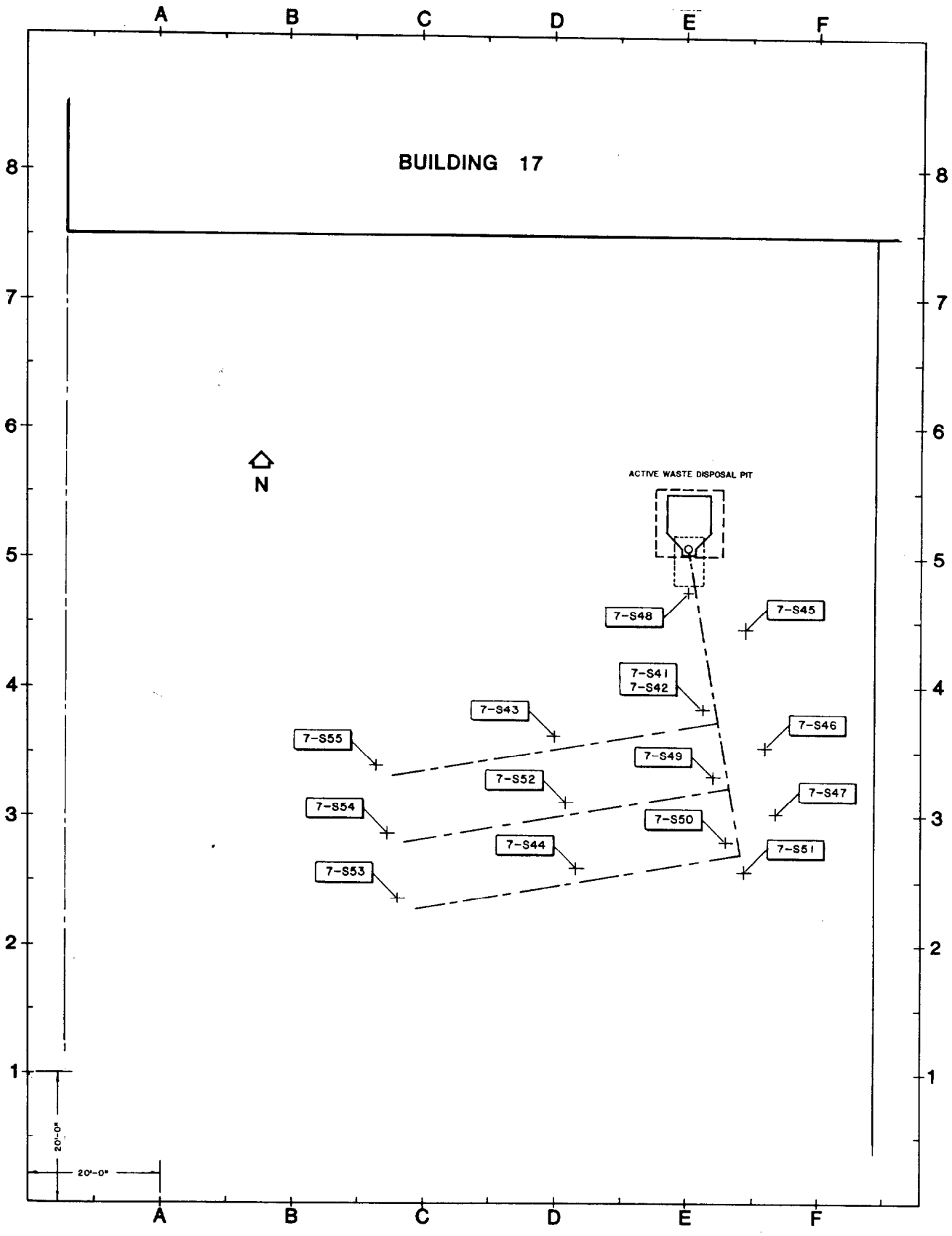

Fig. 39. Working Drawing for Bore Hole Locations

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Lawns Roadways & Docks	100	100						
By Bldgs 2 & 4			1.2×10^6	BKGD[c]	BKGD	BKGD	NST[f]	Location 1 Lawn, base of Bldg. 3
			8.2×10^2	BKGD	BKGD	BKGD	NST	Location 2 North side, lawn
			6.6×10^3	2.2×10^3	0.4	BKGD	NST	Location 3 West side, lawn
			2.2×10^4	BKGD	0.2	BKGD	NST	Location 4 West side, lawn
			1.6×10^4	1.2×10^3	1.2	0.2	NST	Location 5 Lawn
			2.2×10^4	BKGD	5.0	BKGD	NST	Location 6 Due to thorium storage in Bldg. 4
			6.7×10^3	BKGD	0.1	0.1	NST	Location 7 Lawn
By Bldg. 31			9.4×10^3	1.7×10^3	0.4	BKGD	NST	Location 8 Lawn at fence
			3.0×10^3	BKGD	0.2	BKGD	NST	Location 9 Lawn
			3.0×10^3	1.7×10^3	0.2	BKGD	NST	Location 10 Lawn
			1.9×10^3	9.4×10^2	BKGD	BKGD	NST	Location 11 General area on lawn
			1.5×10^3	1.2×10^3	0.5	BKGD	NST	Location 12 Lawn area along dock

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm^2		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm^2	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Lawns, Roadways (cont'd)			2.2×10^4	1.4×10^3	0.8	0.08	NST	Location 13 Lawn area along south dock
By Bldg.28			1.4×10^3	BKGD[c]	0.4	BKGD	NST[f]	Location 14 Driveway east of Bldg. 28
By Bldg.27			2.6×10^3	BKGD	BKGD	BKGD	NST	Location 15 Lawn
By Bldg.22			2.3×10^4	BKGD	0.3	0.15	NST	Location 16 Lawn
			2.3×10^4	BKGD	0.3	BKGD	NST	Location 17 Lawn
By Bldg.4			1.0×10^4	BKGD	0.1	BKGD	NST	Location 18 Lawn
By Bldg.13			1.4×10^3	BKGD	BKGD	BKGD	NST	Location 19 Lawn
By Bldg.34			4.8×10^3	BKGD	BKGD	BKGD	NST	Location 20 General area of lawn
By Bldg.17			6.8×10^4	BKGD	1.0	0.07	NST	Location 21 Lawn

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Lawns, Roadways (cont'd)								
By Bldg.31 Dock			3.5×10^3	BKGD[c]	BKGD	BKGD	$\alpha = 16$[e] $\beta\gamma$=BKGD	Location 22 Asphalt
			1.6×10^4	BKGD	3.0	0.07	BKGD	Location 23 Asphalt on dock
			3.5×10^3	BKGD	BKGD	BKGD	$\alpha = 20$ $\beta\gamma$=BKGD	Location 24 Asphalt on dock
			5.4×10^4	9.4×10^2	1.5	BKGD	$\alpha = 14$ $\beta\gamma$=BKGD	Location 25 Edge of dock
			3.5×10^3	BKGD	0.5	BKGD	BKGD	Location 26 On concrete by
			4.0×10^4	7.4×10^2	BKGD	BKGD	$\alpha = 16$ $\beta\gamma$=BKGD	Location 27 On vertical

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Lawns, Roadways & Docks By Bldg.31 (cont'd)			1.7×10^5	1.7×10^4	BKGD	BKGD[c]	α =19[e] $\beta\gamma$=BKGD	Location 28 Side of Bldg. 31
By Bldgs 27,28,29, and 30			5.9×10^3	BKGD	0.5	BKGD	α =16 $\beta\gamma$=BKGD	Location 29 Lawn and extending 1 m into parking lot
			2.3×10^4	BKGD	0.3	BKGD	α =8 $\beta\gamma$=BKGD	Location 30 Spot on concrete
			7.1×10^3	1.2×10^3	BKGD	BKGD	BKGD	Location 31 Concrete
			5.9×10^3	BKGD	BKGD	BKGD	NST[f]	Location 32 Lawn
			2.3×10^3	BKGD	0.09	BKGD	NST	Location 33 Lawn
			5.9×10^3	BKGD	BKGD	BKGD	α =18 $\beta\gamma$=BKGD	Location 34 Concrete
			5.9×10^3	BKGD	BKGD	BKGD	NST	Location 35 Lawn
			1.1×10^5	7.1×10^3	BKGD	BKGD	BKGD	Location 36 Spot on concrete

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Lawns, Roadways. & Docks By Bldgs. 27, 28, 29, 27,28,29, 30 (cont'd)			$4.1x10^4$	$4.7x10^3$	0.09	BKGD[c]	α =22[e] $\beta\gamma$=BKGD	Location 37 Area on concrete general contamination of $1.2x10^3$ in beta mode
			$9.1x10^4$	$1.7x10^3$	BKGD	BKGD	BKGD	Location 38 Spot on concrete
			$4.3x10^4$	$1.2x10^3$	0.2	BKGD	α =16 $\beta\gamma$=BKGD	Location 39 Spot on concrete
			$4.2x10^4$	$4.7x10^3$	0.06	BKGD	α =18 $\beta\gamma$=BKGD	Location 40 Spot on concrete
			$2.0x10^4$	$1.7x10^3$	0.08	BKGD	α =20 $\beta\gamma$=15	Location 41 Old concrete pad by pipe hole
			$7.4x10^2$	$4.7x10^2$	BKGD	BKGD	BKGD	Location 42 Area of concrete
			$1.6x10^4$	$1.9x10^3$	0.2	BKGD	α =10 $\beta\gamma$=BKGD	Location 43 Spot on concrete
			$5.9x10^3$	$5.9x10^3$	0.5	BKGD	NST[f]	Location 44 In sewer under grate
			$4.6x10^4$	BKGD	0.5	BKGD	NST	Location 45 Side of grate
			$2.0x10^4$	$1.9x10^3$	0.8	BKGD	BKGD	Location 46 Spot on concrete

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm^2		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm^2	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Lawns, Roadways & Docks								
By Bldgs			1.2×10^4	BKGD[c]	1.1	0.3	BKGD	Location 47 Area of dock
21,22,23			1.3×10^5	1.2×10^4	BKGD	BKGD	α =27[e]	Location 48 Spot on dock by
24 & 25							$\beta\gamma$=73	ledge
			4.4×10^4	1.9×10^3	0.1	BKGD	BKGD	Location 49 Spot on concrete
			NRR[g]	NRR	0.5	BKGD	NST[f]	Location 50 Sand in 55 gallon
			8.2×10^3	BKGD	0.8	BKGD	NST	Location 51 Black residue on ground
			7.1×10^2	BKGD	0.13	BKGD	BKGD	Location 52 Barrel of cement
By Bldgs			1.4×10^4	1.6×10^3	0.15	BKGD	BKGD	Location 53 Spot on concrete
5,17 & 34			6.5×10^3	1.4×10^2	0.07	BKGD	BKGD	Location 54 Spot on concrete
			1.5×10^3	BKGD	BKGD	BKGD	BKGD	Location 55 Spot on concrete
			2.1×10^4	BKGD	0.3	BKGD	α =18	Location 56 Spot on concrete
							$\beta\gamma$=BKGD	
			1.1×10^4	BKGD	0.2	BKGD	BKGD	Location 57 Spot on concrete

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Lawns, Roadways & Docks by Bldgs 5,17,&34			3.8×10^3	BKGD[c]	0.1	BKGD	α =14[e] $\beta\gamma$=BKGD	Location 58 Area on concrete general contamination was 1.2×10^3 in beta mode
			1.4×10^3	BKGD	0.7	BKGD	BKGD	Location 59 Spot on concrete
			1.8×10^4	BKGD	0.15	BKGD	NST[f]	Location 60 Spot in dirt
			1.5×10^3	BKGD	BKGD	BKGD	BKGD	Location 61 Spot on concrete
			7.1×10^3	1.9×10^3	BKGD	BKGD	α =5 $\beta\gamma$=BKGD	Location 62 Spot on concrete
Bldg. 1	85	75	NRR[g]	NRR	9.0	.080	NST	Location 69 Sample of thorium, nitrate
			4.7×10^2	BKGD	BKGD	BKGD	BKGD	Location 71 Room 116 area on floor
			3.4×10^4	BKGD[c]	0.3	.075	BKGD	Location 75 Room 109, pitch-blende sample
			NRR[g]	NRR	1.0	.030	NST[f]	Location 81 Ore display
			NRR	NRR	0.2	.030	NST	Location 82 Ore display

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm^2		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm^2	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg. 1 (cont'd.)			1.1×10^3	BKGD	BKGD	15 μR	BKGD	Location 83 Room 306, high reading due to thorium
			NRR	NRR	10	BKGD	NST	Location 95 Room 215, thorium standard
			BKGD	NA[d]	NA	.009	BKGD	Rest of Survey was BKGD
Bldg. 2	85	No Survey	BKGD[c]	NA[d]	NA	BKGD	BKGD	Floor survey only
Bldg. 3	90	80	BKGD	NA	NA	.010	BKGD	Mold Shop
Bldg. 5	80	75	2.3×10^4	1.2×10^4	0.1	BKGD	α =21[e] $\beta\gamma$=44	Location 307 Metal storage room floor
			4.8×10^2	BKGD	BKGD	.005	α =21 $\beta\gamma$=42	Location 320 Overhead beam
			BKGD[c]	NA[d]	NA	.006	BKGD	Rest of Survey was BKGD
Bldg. 6	80	No Survey	BKGD	NA	NA	BKGD	NST[f]	Floor survey only

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm^2		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm^2	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg. 7	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg. 8	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg. 9	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.10	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.11	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.12	80	No Survey	BKGD[c]	NA[d]	NA	BKGD	NST[f]	Floor survey only
Bldg.13	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm^2		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm^2	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg.14	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.15	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.16	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.17	75	70	1.3×10^4	3.0×10^3	BKGD	BKGD	BKGD	Location 297 West Lab 1, spot on floor
			7.1×10^3	4.5×10^3	BKGD	BKGD	BKGD	Location 298 West Lab 1, spot on floor
			4.5×10^3	BKGD	BKGD	30 µR	BKGD	Location 299 West Lab 1, area on floor
			1.7×10^3	1.5×10^2	BKGD	BKGD	BKGD	Location 300 West end Lab 2, spot on floor
			3.2×10^4	2.6×10^3	BKGD	BKGD	BKGD	Location 301 West End Lab 2, spot on floor

Bldg.17 (cont'd)			$1.4x10^5$	BKGD	BKGD	.060	BKGD	Location 289 Possibly due to ore samples stored in loft above
			$1.6x10^3$	BKGD	BKGD	.060	BKGD	Location 290 Floor of corridor next to ore samples
			BKGD	NA[d]	NA	.007	NST[f]	Rest of Survey was BKGD
			BKGD	NA	NA	BKGD	BKGD	Rest of Survey was BKGD
Bldg.18	10	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.19	30	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.20	20	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.21	40	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg.22	40	50	NRR[b]	NRR	15	.010	NST[f]	Location 323 Uranium stored in Specimen Storage Room
			BKGD[c]	NA[d]	NA	.007	BKGD	Rest of Survey was BKGD
Bldg. 23	50	50	4.6×10^4	BKGD[c]	0.2	BKGD	BKGD	Location 222 Spot on wall
			9.4×10^2	4.7×10^2	BKGD	BKGD	α =20[e] $\beta\gamma$=BKGD	Location 223 Trench in floor
			6.9×10^3	1.1×10^2	BKGD	BKGD	α =12 $\beta\gamma$=BKGD	Location 224 Trench in floor
			7.0×10^4	2.4×10^4	BKGD	BKGD	α =16 $\beta\gamma$=BKGD	Location 225 Trench in floor
			1.0×10^3	74	BKGD	BKGD	BKGD	Location 226 Ore Bin Room Spot on first floor
			1.2×10^3	2.9×10^2	BKGD[c]	BKGD	BKGD	Location 238 Spot on floor in basement
			2.2×10^3	3.7×10^2	BKGD	BKGD	BKGD	Location 239 Spot on floor in basement
			BKGD	NA[d]	NA	.008	BKGD	Rest of Survey was BKGD

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm^2		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm^2	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg.24	65	50	BKGD	NA	NA	7 μR	BKGD	All of Survey was BKGD
Bldg.25	50	30	2.0×10^4	2.1×10^4	0.6	BKGD	BKGD	Location 252 Spot on floor
			3.0×10^3	1.2×10^3	BKGD	BKGD	BKGD	Location 257 Spot on floor
			1.2×10^4	1.2×10^3	0.06	BKGD	BKGD	Location 258 Spot on mezzanine floor
			4.7×10^2	4.7×10^2	NRR[g]	NRR	BKGD	Location 259, Northwest overhead beam
			4.2×10^3	1.9×10^3	NRR	NRR	BKGD	Location 260, Northcentral overhead beam
			4.7×10^2	7.1×10^2	NRR	NRR	BKGD	Location 261, North overhead beam
			BKGD	NA	NA	.010	BKGD	Rest of Survey was BKGD
Bldg.26	60	60	2.6×10^3	BKGD[c]	BKGD	BKGD	BKGD	Location 195 Spot on floor
			1.2×10^3	BKGD	0.3	BKGD	BKGD	Location 196 Spot on floor
			BKGD	NA[d]	NA	.007	BKGD	Rest of Survey was BKGD
Bldg.27	80	60	1.5×10^5	3.7×10^2	1.0	.012	α =25[e] $\beta\gamma$=BKGD	Location 217 Room 1, area on floor

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg. 27 (cont'd.)			2.9×10^4	9.8×10^2	0.1	.012	α =14 $\beta\gamma$=BKGD	Location 218 Room 1, area on floor
			1.2×10^3	BKGD	BKGD	BKGD	α =29 $\beta\gamma$=BKGD	Location 219 in Room 3, general floor contamination-
			1.7×10^4	BKGD	BKGD	.007	α =12 $\beta\gamma$=BKGD	Location 221 in Room 2, spot on floor
			BKGD	NA	NA	.007	BKGD	Rest of Survey was BKGD
Bldg.28	60	40	5.2×10^3	9.4×10^2	BKGD[c]	BKGD	α =18[e] $\beta\gamma$=BKGD	Location 171 2nd floor fan platform
			BKGD	BKGD	NA[d]	NRR[b]	α =10 $\beta\gamma$=BKGD	Location 172 Overhead beam, east side of fan platform
			8.9×10^3	2.1×10^3	BKGD	BKGD	α =16 $\beta\gamma$=BKGD	Location 176 Spot on floor

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm^2		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm^2	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg. 28			7.7×10^3	4.5×10^2	BKGD	BKGD	α =16 $\beta\gamma$=BKGD	Location 189 Scale platform
			BKGD	NA	NA	.007	BKGD	Rest of Survey was BKGD
Bldg.30 (Room 8 only)	40	40	9.4×10^3	BKGD	NRR	.010	BKGD	Location 134 Room 8, Spot on floor. This was the only room surveyed in Bldg. 30.
			BKGD	NA	NA	.008	BKGD	The rest of the survey
Bldg.31	60	55	6.7×10^2	BKGD	0.5	BKGD	α =14[e] $\beta\gamma$=BKGD	Location 136 Spot on floor
			3.2×10^3	BKGD	0.1	BKGD	α =BKGD $\beta\gamma$=110	Location 137 Spot on floor
			3.1×10^3	1.5×10^3	0.1	BKGD	α =5 $\beta\gamma$=BKGD	Location 138 Spot on floor

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg. 31 (cont'd.)			8.7×10^3	BKGD	0.3	BKGD	BKGD	Location 142 in Room 15 Spot on floor
			5.4×10^3	1.2×10^3	BKGD	BKGD	α =14 $\beta\gamma$=BKGD	Location 143 On grate
			2.3×10^2	1.2×10^3	BKGD	BKGD	BKGD	Location 144 Spot on over-head beam
			1.6×10^4	2.4×10^3	BKGD[c]	BKGD	α =16[e] $\beta\gamma$=BKGD	Location 145 Spot on over-head duct
			9.4×10^2	BKGD	BKGD	BKGD	BKGD	Location 151 Room 13, Spot in sewer pipe
			1.4×10^3	BKGD	BKGD	BKGD	BKGD	Location 152 Spot on wall
			4.2×10^3	BKGD	0.5	BKGD	α =31 $\beta\gamma$=BKGD	Location 157 Spot in cup drain
			2.4×10^2	4.7×10^2	BKGD	BKGD	α =82 $\beta\gamma$=BKGD	Location 161 2nd floor loft cross beam

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm²		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm²	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Bldg. 31 (cont'd.)			4.7×10^3	1.6×10^3	NRR[b]	NRR	α =17 $\beta\gamma$=BKGD	Location 188, Spot on wall of the floor trench
			4.7×10^2	4.7×10^2	BKGD	BKGD	BKGD	Location 162 2nd floor loft cross beam
			BKGD	NA[d]	NA	.008	BKGD	Rest of Survey was BKGD
Bldg.32	60	No Survey	BKGD	NA[d]	NA	BKGD	NST[(f)]	Floor survey only
Bldg.33	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
Bldg.34	80	No Survey	BKGD	NA	NA	BKGD	NST	Floor survey only
					Racine, WI			
Sewer 1371					0.0785			
Sewer 1376					0.0393			

TABLE 1

INSTRUMENT SURVEY RESULTS

Room No. or Area	Percent of Area Accessible for Survey		Direct Readings,[a] dis/min-100 cm^2		Beta Gamma Exposure Level, mR/h		Smears, dis/min-100 cm^2	Comments
	Floors	Walls	Beta	Alpha	Contact	1 Meter		
Sewer 1380					0.0096			
Sewer 1385					0.0035			
Sewer 1387					0.0018			
Sewer 1388					0.0582			

FOOTNOTES FOR TABLE 1

... are to be compared with the pertinent guidelines identified in

...mode Direct Readings and Alpha Mode Direct Readings are taken with ... instruments. The beta mode detects both electromagnetic and particu... If an area indicated a higher count rate than the instrument ... beta-mode reading was obtained. The instrument was then switched ...a mode, and a reading of the alpha contamination was obtained. In ...mode the instrument only responds to particles with high specific ... such as alpha particles.

...mode readings are compensated for any alpha contribution by subtract... mode reading from the beta-mode reading.

...ing Recorded.

...kground) The following are the instrument background readings:

Beta-Mode	Alpha Mode
1500-2000 cts/min-325 cm^2	0-50 cts/min-325 cm^2
150-200 cts/min-51 cm^2	0-50 cts/min-51 cm^2
40.0 ± 1.4 cts/min*	0.2 ± 0.1 cts/min*
40.0 ± 1.7 cts/min*	0.3 ± 0.1 cts/min*
443.0 ± 4.7 cts/min*	5.2 ± 0.5 cts/min*

...detector read 0.03 to 0.05 mR/h at 1 m above floor.

... / μR/h at 1 m above floor.

...ilable) No contamination was detected above background in the beta ... no alpha mode or contact GM End Window survey was necessary.

...mma ...mma readings are comepnsated for any alpha contamination by sub... reading from the beta-gamma reading.)

...ard.

...ation due to counting statistics.

TABLE 2

LOOSE CONTAMINATION
(INTERIOR AND EXTERIOR)

Location Number	Item Smeared	Smear Results[a] dis/min-100 cm^2 Alpha	Beta-gamma
INTERIOR			
307	Floor	21	44
320	Overhead beam	21	42
223	Floor trench	20	BKGD[b]
224	Floor trench	12	BKGD
225	Floor trench	16	~~28~~ BKGD
217	Floor	25	BKGD
218	Floor	14	BKGD
219	Floor	29	BKGD
221	Floor	12	BKGD
171	Fan platform	18	BKGD
172	Overhead beam east side of fan platform	10	BKGD
176	Floor	16	BKGD
189	Scale platform in basement	16	BKGD
136	Floor	14	BKGD
137	Floor	BKGD	110
138	~~BKGD~~ Floor	5	BKGD
143	Grate	14	BKGD
145	Overhead duct	16	BKGD
157	Cup drain	31	BKGD
161	Floor loft on cross beam	81 ~~79~~	~~426~~ BKGD
188	Floor trench	17	BKGD

TABLE 2
(cont'd.)

Location Number	Item Smeared	Smear Results dis/min-100 cm^2 Alpha	Beta-Gamma
EXTERIOR			
22	Asphalt	16	BKGD[b]
24	Dock	20	BKGD
25	Dock	14	BKGD
27	Building	16	BKGD
28	Building	19	BKGD
29	Lawn	16	BKGD
30	Concrete	8	BKGD
34	Concrete	18	BKGD
37	Concrete	32	BKGD
39	Concrete	16	BKGD
40	Concrete	18	BKGD
41	Concrete pad by pipe hole	20	15
43	Dock	10 27	BKGD
48	Dock	27	73
56	Concrete	18	BKGD
58	Concrete	14	BKGD
62	Concrete	5	BKGD

[a] See Appendix 6 for pertinent guidelines.

[b] The count was not greater than the instrument background.

TABLE 3

CONTAMINATED AREAS - INTERIOR AND EXTERIOR

Room Number	Location Number	Estimated Area of Contamination (cm^2)	Maximum PAC Reading (dis/min-100 cm^2) Beta-Gamma	Alpha	Contact GM Reading (mR/h)	Smear Results (dis/min-100 cm^2) Beta-Gamma	Alpha
INTERIOR							
Bldg. 1	71		4.7×10^2	BKGD	BKGD	BKGD	BKGD
Bldg. 5	307	2×10^3	1.3×10^4	1.2×10^4	0.1	21	44
	320		4.8×10^2	BKGD	BKGD	21	42
Bldg. 17	297	1×10^3	1.3×10^4	3.0×10^3	BKGD	BKGD	BKGD
	298	1×10^3	7.1×10^3	4.5×10^3	BKGD	BKGD	BKGD
	299		4.5×10^3	BKGD	BKGD	BKGD	BKGD
	300		1.7×10^3	1.5×10^2	BKGD	BKGD	BKGD
	301	1×10^3	3.2×10^4	2.6×10^3	BKGD	BKGD	BKGD
Bldg. 23	206		1.0×10^3	74	BKGD	BKGD	BKGD
	222	1.5×10^3	4.6×10^4	BKGD	0.2	BKGD	BKGD
	223		9.4×10^2	4.7×10^2	BKGD	20	BKGD
	224	1.5×10^3	6.9×10^3	110	BKGD	12	BKGD
	225	1.5×10^3	7.0×10^4	2.4×10^4	BKGD	16	BKGD
	238		1.2×10^3	2.9×10^2	BKGD	BKGD	BKGD
	239		2.2×10^3	3.7×10^2	BKGD	BKGD	BKGD
Bldg. 25	252	2×10^3	2.0×10^4	2.1×10^4	0.6	BKGD	BKGD
	257		3.0×10^3	4.7×10^3	BKGD	BKGD	BKGD
	258	1×10^3	1.2×10^4	1.2×10^3	0.06	BKGD	BKGD
	259		4.7×10	4.7×10^2		BKGD	BKGD
	260		4.2×10^3	1.9×10^3		BKGD	BKGD
	261		4.7×10^2	7.1×10^2		BKGD	BKGD
Bldg. 26	195		2.6×10^3	BKGD	BKGD	BKGD	BKGD
	196		1.2×10^3	BKGD	0.3	BKGD	BKGD

TABLE 3. (Cont'd.)

Room Number	Location Number	Estimated Area of Contamination (cm^2)	Maximum PAC Reading (dis/min-100 cm^2) Beta-Gamma	Maximum PAC Reading (dis/min-100 cm^2) Alpha	Contact GM Reading (mR/h)	Smear Results (dis/min-100 cm^2) Beta-Gamma	Smear Results (dis/min-100 cm^2) Alpha
Bldg. 27	217	7.5×10^4	1.5×10^5	370	1.0	25	BKGD
	218	2.5×10^4	2.9×10^4	980	0.1	BKGD	14
	219		1.2×10^3	BKGD	BKGD	BKGD	29
	221	1×10^3	1.7×10^4	BKGD	BKGD	BKGD	12
Bldg. 28	171	1×10^3	5.2×10^3	9.4×10^2	BKGD	BKGD	18
	176	1×10^3	8.9×10^3	2.1×10^3	BKGD	BKGD	16
	189	2×10^3	7.7×10^3	4.5×10^2	BKGD	BKGD	16
Bldg. 30	134		9.4×10^3	BKGD		BKGD	BKGD
Bldg. 31	136		6.7×10^2	BKGD	0.5	BKGD	14
	137		3.2×10^3	BKGD	0.1	BKGD	110
	138		3.1×10^3	1.5×10^3	0.1	BKGD	5
	142	1×10^3	8.7×10^3	BKGD	0.3	BKGD	BKGD
	143	1×10^3	5.4×10^3	1.2×10^3	BKGD	BKGD	14
	144		2.3×10^2	1.2×10^3	BKGD	BKGD	BKGD
	145	3×10^2	1.6×10^4	2.4×10^3	BKGD	BKGD	16
	151		9.4×10^2	BKGD	BKGD	BKGD	BKGD
	152		1.4×10^3	BKGD	BKGD	BKGD	BKGD
	157		4.2×10^3	BKGD	0.5	BKGD	31
	161		2.4×10^2	4.7×10^2	BKGD	BKGD	82
	188		4.7×10^3	1.6×10^3		BKGD	17
	162		4.7×10^2	4.3×10^2	BKGD	BKGD	BKGD
EXTERIOR							
Lawn	1	3×10^3	1.2×10^6	BKGD	BKGD		
	2		8.2×10^2	BKGD	BKGD		
	3	3×10^4	6.6×10^3	2.2×10^3	0.4		
	4	3×10^4	2.2×10^4	BKGD	0.2		
	5	3×10^4	1.6×10^4	1.2×10^3	1.2		
	7	1×10^4	6.7×10^3	BKGD	0.1		
	8	3×10^3	9.4×10^3	1.7×10^3	0.4		
	9		3.0×10^3	BKGD	0.2		

TABLE 3. (Cont'd.)

Room Number	Location Number	Estimated Area of Contamination (cm^2)	Maximum PAC Reading (dis/min-100 cm^2) Beta-Gamma	Maximum PAC Reading (dis/min-100 cm^2) Alpha	Contact GM Reading (mR/h)	Smear Results (dis/min-100 cm^2) Beta-Gamma	Smear Results (dis/min-100 cm^2) Alpha
Lawn	10		$3.0x10^3$	$1.7x10^3$	0.2		
(cont'd.)	11		$1.9x10^3$	$9.4x10^2$	BKGD		
	12		$1.5x10^3$	$1.2x10^3$	0.5		
	13	$2x10^4$	$2.2x10^4$	$1.4x10^3$	0.8		
	14		$1.4x10^3$	BKGD	0.4		
	15		$2.6x10^3$	BKGD	BKGD		
	16	$5x10^3$	$2.3x10^4$	BKGD	0.3		
	17	$5x10^3$	$2.3x10^4$	BKGD	0.3		
	18	$5x10^3$	$1.0x10^4$	BKGD	0.1		
	19		$1.4x10^3$	BKGD	BKGD		
	20		$4.8x10^3$	BKGD	BKGD		
	21	$1x10^4$	$6.8x10^4$	BKGD	1.0		
	22		$3.5x10^3$	BKGD	BKGD	BKGD	16
Bldg. 31	23	$4x10^3$	$1.6x10^4$	BKGD	3.0		
Dock	24		$3.5x10^3$	BKGD	BKGD	BKGD	20
	25	$3x10^3$	$5.4x10^4$	940	1.5	BKGD	14
	26		$3.5x10^3$	BKGD	0.5	BKGD	BKGD
	27	$1x10^4$	$4.0x10^4$	740	BKGD	BKGD	16
	55		$1.5x10^3$	BKGD	BKGD	BKGD	BKGD
	58		$3.8x10^3$	BKGD	0.1	BKGD	14
	59		$1.4x10^3$	BKGD	0.7	BKGD	BKGD
	61		$1.5x10^3$	BKGD	BKGD	BKGD	BKGD
Site of Bldg. 31	28	$1x10^3$	$1.7x10^5$	$1.7x10^4$	BKGD	BKGD	19
Lawn	29	$1.5x10^5$	$5.9x10^3$	BKGD	0.5	BKGD	16
Concrete	30	$1x10^2$	$2.3x10^4$	BKGD	0.3	BKGD	8
	31	$1x10^3$	$7.1x10^3$	$1.2x10^3$	BKGD	BKGD	BKGD
Lawn	32	$2x10^3$	$5.9x10^3$	BKGD	BKGD		
	33		$2.3x10^3$	BKGD	0.09		

TABLE 3 - (cont'd.)

Room Number	Location Number	Estimated Area of Contamination (cm^2)	Maximum PAC Reading (dis/min-100 cm^2) Beta-Gamma	Maximum PAC Reading (dis/min-100 cm^2) Alpha	Contact GM Reading (mR/h)	Smear Results (dis/min-100 cm^2) Beta-Gamma	Smear Results (dis/min-100 cm^2) Alpha
Concrete	34	$1x10^3$	$5.9x10^3$	BKGD	BKGD	BKGD	18
Lawn	35	$1x10^3$	$5.9x10^3$	BKGD	BKGD		
Concrete	36	$1x10^3$	$1.1x10^5$	$7.1x10^3$	BKGD	BKGD	BKGD
	37	$6x10^4$	$4.1x10^4$	$4.7x10^3$	0.09	BKGD	22
	38	$1x10^3$	$9.1x10^4$	$1.7x10^3$	BKGD	BKGD	BKGD
	39	$1x10^3$	$4.3x10^4$	$1.2x10^3$	0.2	BKGD	16
	40	$1x10^3$	$4.2x10^4$	$4.7x10^3$	0.06	BKGD	18
	41	$9x10^3$	$2.0x10^4$	$1.7x10^3$	0.08	~~BKGD~~ 15	20
	42		$7.4x10^2$	$7.4x10^2$	BKGD	BKGD	BKGD
	43	$1x10^3$	$1.6x10^4$	$1.9x10^3$	0.2	BKGD	10
Sewer Grate	44	$1x10^3$	$5.9x10^3$	$5.9x10^3$	0.5		
	45	$3x10^2$	$4.6x10^4$	BKGD	0.5		
Concrete	46	$1x10^3$	$2.0x10^4$	$1.9x10^3$	0.8	BKGD	BKGD
Bldg. 22	47	$3x10^3$	$1.2x10^4$	BKGD	1.1	BKGD	BKGD
Dock	48	$1x10^3$	$1.3x10^5$	$1.2x10^4$	BKGD	73	27
Concrete	49	$1x10^3$	$4.4x10^4$	$1.9x10^3$	0.1	BKGD	BKGD
Black Residue	51	$1x10^3$	$8.2x10^3$	BKGD	0.8		
Concrete	53	$1x10^3$	$1.4x10^4$	$1.6x10^3$	0.15	BKGD	BKGD
	54	$1x10^3$	$6.5x10^3$	140	0.07	BKGD	BKGD
	56	$2x10^3$	$2.1x10^4$	BKGD	0.3	BKGD	18
	57	$2x10^3$	$1.1x10^4$	BKGD	0.32	BKGD	BKGD
Dirt	60	$3x10^3$	$1.8x10^4$	BKGD	0.15		
Concrete	62	$9x10^3$	$7.1x10^3$	$1.9x10^3$	BKGD	BKGD	5

TABLE 4

RADON-CONCENTRATION DETERMINATIONS

Sample Number	Location	WL[a]	Radon (^{222}Rn) pCi/ℓ
1	Bldg. 1 by Room 11	0.0067	0.67
2	Bldg. 1 2nd Floor	0.0042	0.42
3	Bldg. 1 by Room 306	0.0017	0.17
4	Bldg. 30 Room 8	0.0042	0.42
5	Bldg. 31 Room 15	0.0082	0.82
6	Bldg. 31 Room 15	0.0004	0.04
7	Bldg. 31 Loft	0.0036	0.36
8	Bldg. 28 Service Floor	0.0025	0.25
9	Bldg. 28 Room 15	0.0023	0.23
10	Bldg. 28 2nd Floor	0.0004	0.04
11	Bldg. 23 Main Floor Trenches	0.0028	0.28
12	Bldg. 23 Storeroom	0.0021	0.21
13	Bldg. 23 Ore Room	0.0168	1.68
14	Bldg. 23 Basement	0.0122	1.22
15	Bldg. 27 Room 1	0.0030	0.30
16	Bldg. 26 Room 103	0.0013	0.13
17	Bldg. 26 2nd Floor Corridor	0.0016	0.16
18	Bldg. 25 2nd Floor	0.0013	0.13
19	Bldg. 5 Metal Storage Area	0.0031	0.31
20	Bldg. 17 West End Lab 1	0.0031	0.31
21	Bldg. 24 1st Floor	0.0055	0.55
22	Bldg. 22 Warehouse	0.0026	0.26
23	Bldg. 3 Room 1	0.0045	0.45
24	Sanitary Sewer 1393	0.0032	0.32
25	Sanitary Sewer 1392	0.0882	8.82
26	Sanitary Sewer 1393	0.0045	0.45
27	Sanitary Sewer 1391	0.1302	13.02
28	Sanitary Sewer 1385	0.0035	0.35
29	Sanitary Sewer 1541	0.0032	0.32
30	Sanitary Sewer 1387	0.0018	0.18
31	Sanitary Sewer 1388	0.0582	5.82
32	Sanitary Sewer 1380	0.0096	0.96
33	Sanitary Sewer 1376	0.0393	3.93
34	Sanitary Sewer 1371	0.0785	7.85
35	Sanitary Sewer 1540	0.0060	0.60

[a] A Working Level (WL) is defined in 10 CFR 712 as any combination of short-lived radon-daughter products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy. The numerical value of the WL is derived from the alpha energy released by the total decay through RaC' of the short-lived radon-daughter products, RaA, RaB, and RaC at radioactive equilibrium with 100 pCi of ^{222}Rn per liter of air. These values are to be compared with the limit of 0.02 WL for average annual concentration as specified in the EPA Standard (see Appendix 6).

TABLE 5

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
			BACKGROUND SOIL CORINGS		
7-SB1-A	1.64 ± 0.08	0.80 ± 0.12	0.68 ± 0.08	1.6 ± 1.0	1.1 ± 0.7
7-SB1-B				3.5 ± 1.0	2.4 ± 0.7
7-SB1-C				2.3 ± 1.1	1.6 ± 0.8
7-SB1-D				2.8 ± 1.4	2.0 ± 1.0
7-SB2-A	0.95 ± 0.05	0.81 ± 0.08	0.84 ± 0.15	2.6 ± 1.2	1.8 ± 0.8
7-SB2-B				0.6 ± 1.0	0.4 ± 0.7
7-SB2-C				2.0 ± 1.2	1.4 ± 0.8
7-SB2-D				1.1 ± 1.2	0.8 ± 0.8
7-SB3-A	1.38 ± 0.07	1.12 ± 0.12	0.83 ± 0.07	4.2 ± 1.3	2.9 ± 0.9
7-SB3-B				1.7 ± 1.3	1.2 ± 0.9
7-SB3-C				0.9 ± 1.3	0.6 ± 0.9
7-SB3-D				1.5 ± 1.4	1.0 ± 1.0
7-SB4-A	0.85 ± 0.08	1.19 ± 0.20	0.93 ± 0.13	2.4 ± 1.4	1.7 ± 1.0
7-SB4-B				2.3 ± 1.3	1.6 ± 0.9
7-SB4-C				2.8 ± 1.3	2.0 ± 0.9
7-SB4-D				4.0 ± 1.2	2.8 ± 0.8
			SOIL CORINGS		
7-S5-A	0.71 ± 0.18	0.46 ± 0.15	0.40 ± 0.12	1.9 ± 1.1	1.3 ± 0.8
7-S5-B				6.7 ± 1.3	4.7 ± 0.9
7-S5-C				1.3 ± 1.3	0.9 ± 0.9
7-S5-D				2.7 ± 1.4	1.9 ± 1.0
7-S6-A	0.80 ± 0.08	0.61 ± 0.12	0.58 ± 0.08	2.1 ± 1.2	1.5 ± 0.8
7-S6-B				2.5 ± 1.1	1.7 ± 0.8
7-S6-C				1.6 ± 1.3	1.1 ± 0.9
7-S6-D				1.5 ± 1.3	1.0 ± 0.9
7-S7-A	0.74 ± 0.07	0.70 ± 0.15	0.57 ± 0.10	1.9 ± 1.3	1.3 ± 0.9
7-S7-B				3.1 ± 1.3	2.2 ± 0.9
7-S7-C				1.8 ± 1.3	1.3 ± 0.9
7-S7-D				6.9 ± 1.4	4.8 ± 1.0
7-S8-A	0.95 ± 0.09	1.36 ± 0.19	0.76 ± 0.12	2.2 ± 1.2	1.5 ± 0.8
7-S8-B				2.1 ± 1.4	1.5 ± 1.0
7-S8-C				1.2 ± 1.2	0.8 ± 0.8
7-S8-D				1.1 ± 1.3	0.8 ± 0.9

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ			Uranium Fluorometric	
	^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	μg/g ± σ	pCi/g ± σ
			SOIL CORINGS - (cont'd.)		
7-S9-A	0.52 ± 0.06	0.68 ± 0.14	0.63 ± 0.08	2.4 ± 1.3	1.7 ± 0.9
7-S9-B				2.3 ± 1.3	1.6 ± 0.9
7-S9-C				1.8 ± 1.4	1.3 ± 1.0
7-S9-D				2.1 ± 1.3	1.5 ± 0.9
7-S10-A	0.01 ± 1.4	637 ± 32	2.03 ± 1.10	1.8 ± 1.4	1.3 ± 1.0
7-S10-B				2.6 ± 1.4	1.8 ± 1.0
7-S10-C				2.8 ± 1.5	2.0 ± 1.0
7-S10-D				5.8 ± 1.5	4.1 ± 1.0
7-S11-A	0.73 ± 0.18	57.4 ± 2.9	0.81 ± 0.21	3.4 ± 1.5	2.4 ± 1.0
7-S11-B				4.6 ± 1.2	3.2 ± 0.8
7-S11-C				3.3 ± 1.4	2.3 ± 1.0
7-S11-D				1.7 ± 1.2	1.2 ± 0.8
7-S12-A	0.0 ± 0.69	136 ± 7.0	0.55 ± 0.38	5.1 ± 1.1	3.6 ± 0.8
7-S12-B				3.1 ± 1.0	2.2 ± 0.7
7-S12-C				8.0 ± 1.0	5.6 ± 0.7
7-S12-D				2.5 ± 1.1	1.7 ± 0.8
7-S13-A	0.43 ± 0.07	0.48 ± 0.11	0.54 ± 0.08	1.8 ± 1.1	1.3 ± 0.8
7-S13-B				2.5 ± 1.2	1.7 ± 0.8
7-S13-C				4.2 ± 1.4	2.9 ± 1.0
7-S13-D				3.0 ± 1.2	2.1 ± 0.8
7-S14-A	0.82 ± 0.05	1.12 ± 0.11	0.63 ± 0.06	3.6 ± 1.2	2.5 ± 0.8
7-S14-B				3.8 ± 1.2	2.7 ± 0.8
7-S14-C				3.0 ± 1.3	2.1 ± 0.9
7-S14-D				2.6 ± 1.1	1.8 ± 0.8
7-S15-A	0.84 ± 0.09	1.29 ± 0.22	0.79 ± 0.13	2.6 ± 1.3	1.8 ± 0.9
7-S15-B				2.5 ± 1.3	1.7 ± 0.9
7-S15-C				3.2 ± 1.3	2.2 ± 0.9
7-S15-D				5.0 ± 1.0	3.5 ± 0.7
7-S16-A	0.47 ± 0.06	0.90 ± 0.15	0.81 ± 0.09	2.3 ± 1.2	1.6 ± 0.8
7-S16-B				3.8 ± 1.1	2.7 ± 0.8
7-S16-C				1.6 ± 1.2	1.1 ± 0.8
7-S16-D				3.0 ± 1.1	2.1 ± 0.8

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
			SOIL CORINGS - (cont'd.)		
7-S17-A	0.23 ± 0.03	1.92 ± 0.10	5.47 ± 0.27	34 ± 3	23.8 ± 2
7-S17-B				13 ± 2	9.1 ± 2
7-S17-C				7.5 ± 1.5	5.3 ± 1.0
7-S17-D				4.9 ± 1.2	3.4 ± 0.8
7-S18-A	2.18 ± 0.11	23.0 ± 1.2	0.63 ± 0.13	2.9 ± 1.2	2.0 ± 0.8
7-S18-B				2.7 ± 1.2	1.9 ± 0.8
7-S18-C				2.7 ± 1.3	1.9 ± 0.9
7-S18-D				1.9 ± 1.0	1.3 ± 0.7
7-S19-A	1.25 ± 0.09	0.84 ± 0.19	0.78 ± 0.13	3.0 ± 1.5	2.1 ± 1.0
7-S19-B				3.5 ± 1.5	2.4 ± 1.0
7-S19-C				3.7 ± 1.4	2.6 ± 1.0
7-S19-D				3.4 ± 1.3	2.4 ± 0.9
7-S20-A	0.70 ± 0.13	17.4 ± 0.9	0.49 ± 0.20	4.4 ± 1.3	3.1 ± 0.9
7-S20-B				2.8 ± 1.2	2.0 ± 0.8
7-S20-C				3.8 ± 1.4	2.7 ± 1.0
7-S20-D				3.4 ± 1.5	2.4 ± 1.0
7-S21-A	1.17 ± 0.08	2.48 ± 0.22	0.62 ± 0.12	2.5 ± 1.4	1.7 ± 1.0
7-S21-B				1.1 ± 1.2	0.8 ± 0.8
7-S21-C				2.6 ± 1.4	1.8 ± 1.0
7-S21-D				2.9 ± 1.3	2.0 ± 0.9
7-S22-A	2.50 ± 0.15	13.6 ± 0.7	0.57 ± 0.20	13 ± 2	9.1 ± 1
7-S22-B				25 ± 3	17.4 ± 2
7-S22-C				3.9 ± 1.0	2.7 ± 0.7
7-S22-D				3.8 ± 1.4	2.7 ± 1.0
7-S23-A	2.44 ± 0.19	20.3 ± 1.1	1.00 ± 0.26	52 ±16	36.3 ± 11
7-S23-B				6.4 ± 1.2	4.5 ± 0.8
7-S23-C				2.9 ± 1.0	2.0 ± 0.7
7-S23-D				2.4 ± 1.3	1.7 ± 0.9
7-S24-A	1.19 ± 0.7	0.67 ± 0.15	0.61 ± 0.10	3.9 ± 1.2	2.7 ± 0.8
7-S24-B				3.4 ± 1.1	2.4 ± 0.8
7-S24-C				6.5 ± 1.4	4.5 ± 1.0
7-S24-D				3.0 ± 1.2	2.1 ± 0.8

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
			SOIL CORINGS - (cont'd.)		
7-S25-A	1.17 ± 0.08	1.44 ± 0.14	0.88 ± 0.08	3.6 ± 1.2	2.5 ± 0.8
7-S25-B				6.2 ± 1.3	4.3 ± 0.9
7-S25-C				2.3 ± 1.1	1.6 ± 0.8
7-S25-D				1.7 ± 1.2	1.2 ± 0.8
7-S25-E				1.6 ± 1.2	1.1 ± 0.8
7-S33-A	0.39 ± 0.03	0.60 ± 0.06	0.51 ± 0.04	1.5 ± 0.15	1.0 ± 0.1
7-S33-B	0.44 ± 0.03	0.38 ± 0.07	0.73 ± 0.05	1.3 ± 0.13	0.9 ± 0.09
7-S33-C	0.38 ± 0.03	0.93 ± 0.06	0.75 ± 0.05	1.4 ± 0.14	1.0 ± 01
7-S33-D	0.03 ± 0.02	0.65 ± 0.65	0.72 ± 0.05	2.4 ± 0.24	1.7 ± 0.17
7-S34-A	0.85 ± 0.06	7.37 ± 0.52	0.70 ± 0.05	2.1 ± 0.21	1.5 ± 0.15
7-S34-B	0.66 ± 0.05	1.09 ± 0.08	0.84 ± 0.06	2.0 ± 0.2	1.4 ± 0.14
7-S34-C	0.28 ± 0.04	1.40 ± 0.10	0.79 ± 0.06	2.1 ± 0.21	1.5 ± 0.15
7-S34-D	<0.03	1.12 ± 0.08	0.82 ± 0.06	2.0 ± 0.2	1.4 ± 0.14
7-S35-A	0.18 ± 0.04	1.20 ± 0.08	1.33 ± 0.09	1.9 ± 0.19	1.3 ± 0.13
7-S35-B	0.18 ± 0.04	1.32 ± 0.09	1.40 ± 0.10	1.9 ± 0.19	1.3 ± 0.13
7-S35-C	0.19 ± 0.04	1.14 ± 0.08	1.50 ± 0.11	1.9 ± 0.19	1.3 ± 0.13
7-S35-D	0.10 ± 0.03	1.29 ± 0.09	1.41 ± 0.10	2.2 ± 0.22	1.5 ± 0.15
7-S36-A	0.22 ± 0.04	0.94 ± 0.07	0.72 ± 0.05	1.8 ± 0.18	1.3 ± 0.13
7-S36-B	0.28 ± 0.04	0.90 ± 0.06	0.70 ± 0.04	1.8 ± 0.18	1.3 ± 0.13
7-S36-C	0.20 ± 0.04	1.13 ± 0.08	1.33 ± 0.09	2.0 ± 0.2	1.4 ± 0.14
7-S36-D	0.17 ± 0.04	1.04 ± 0.07	0.80 ± 0.06	1.7 ± 0.17	1.2 ± 0.12
7-S37-A	0.16 ± 0.04	1.24 ± 0.09	1.53 ± 0.09	1.4 ± 0.14	1.0 ± 0.1
7-S37-B	0.24 ± 0.04	1.02 ± 0.07	0.65 ± 0.05	1.7 ± 0.17	1.2 ± 0.12
7-S37-C	0.43 ± 0.03	0.87 ± 0.06	1.27 ± 0.09	1.7 ± 0.17	1.2 ± 0.12
7-S37-D	0.08 ± 0.03	1.23 ± 0.09	1.20 ± 0.08	1.6 ± 0.16	1.2 ± 0.12
7-S38-A	0.28 ± 0.04	1.17 ± 0.08	0.98 ± 0.07	1.9 ± 0.19	1.3 ± 0.13
7-S38-B	0.31 ± 0.03	0.85 ± 0.06	0.91 ± 0.06	1.9 ± 0.19	1.3 ± 0.13
7-S38-C	0.29 ± 0.04	1.32 ± 0.09	1.40 ± 0.10	2.0 ± 0.20	1.4 ± 0.14
7-S38-D	0.22 ± 0.04	1.04 ± 0.07	0.97 ± 0.07	2.1 ± 0.21	1.5 ± 0.15

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
		SOIL BORINGS			
7-S41-1.0	0.07 ± 0.03	1.09 ± 0.08	1.06 ± 0.07	2.0 ± 0.2	1.40 ± 0.14
7-S41-2.0	0.11 ± 0.03	1.27 ± 0.09	0.91 ± 0.07	2.0 ± 0.2	1.40 ± 0.14
7-S41-3.0	<0.03	0.89 ± 0.07	0.98 ± 0.07	2.1 ± 0.21	1.47 ± 0.147
7-S41-4.0	0.05 ± 0.02	1.19 ± 0.08	0.30 ± 0.03	2.1 ± 0.21	1.47 ± 0.147
7-S41-5.0	0.13 ± 0.04	1.18 ± 0.08	0.91 ± 0.07	3.6 ± 0.36	2.52 ± 0.252
7-S42-1.0	0.19 ± 0.04	1.19 ± 0.08	1.20 ± 0.08	2.0 ± 0.02	1.40 ± 0.14
7-S42-2.0	<0.03	0.88 ± 0.07	1.16 ± 0.08	2.1 ± 0.21	1.47 ± 0.147
7-S42-3.0	0.15 ± 0.04	1.12 ± 0.08	0.87 ± 0.07	2.0 ± 0.2	1.40 ± 0.14
7-S42-4.0	<0.03	1.24 ± 0.09	1.39 ± 0.10	2.2 ± 0.22	1.54 ± 0.154
7-S42-5.0	0.09 ± 0.03	1.34 ± 0.09	1.13 ± 0.08	2.2 ± 0.22	1.54 ± 0.154
7-S42-6.0	<0.03	1.50 ± 0.11	1.36 ± 0.10	2.4 ± 0.24	1.68 ± 0.168
7-S42-7.0	<0.03	1.65 ± 0.12	1.08 ± 0.08	2.6 ± 0.26	1.82 ± 0.182
7-S42-8.0	<0.03	1.50 ± 0.10	1.35 ± 0.09	2.0 ± 0.2	1.40 ± 0.140
7-S42-9.0	<0.03	1.23 ± 0.09	1.22 ± 0.09	2.2 ± 0.22	1.54 ± 0.154
7-S42-10.0	<0.03	0.78 ± 0.07	0.81 ± 0.07	1.8 ± 0.18	1.26 ± 0.126
7-S43-1.0	0.04 ± 0.02	1.07 ± 0.07	1.08 ± 0.08	2.2 ± 0.22	1.54 ± 0.154
7-S43-2.0	0.07 ± 0.03	1.20 ± 0.08	1.30 ± 0.09	2.1 ± 0.21	1.47 ± 0.147
7-S43-3.0	0.16 ± 0.03	1.52 ± 0.11	0.98 ± 0.07	2.1 ± 0.21	1.47 ± 0.147
7-S43-4.0	0.03 ± 0.02	1.04 ± 0.07	0.95 ± 0.07	2.0 ± 0.2	1.40 ± 0.14
7-S43-5.0	<0.03	1.33 ± 0.09	1.24 ± 0.09	2.1 ± 0.21	1.47 ± 0.147
7-S43-6.0	<0.03	0.99 ± 0.07	1.10 ± 0.08	2.1 ± 0.21	1.47 ± 0.147
7-S43-7.0	<0.03	1.26 ± 0.09	1.04 ± 0.07	2.0 ± 0.2	1.40 ± 0.14
7-S43-8.0	<0.03	1.52 ± 0.11	1.41 ± 0.10	2.2 ± 0.22	1.54 ± 0.154
7-S43-9.0	<0.03	1.17 ± 0.08	1.08 ± 0.08	1.9 ± 0.19	1.33 ± 0.133
7-S43-10.0	<0.03	0.79 ± 0.06	0.66 ± 0.05	1.7 ± 0.17	1.19 ± 0.119
7-S44-1.0	0.20 ± 0.04	1.27 ± 0.09	1.31 ± 0.09	2.2 ± 0.22	1.54 ± 0.154
7-S44-2.0	0.11 ± 0.03	1.17 ± 0.08	1.00 ± 0.07	1.8 ± 0.18	1.26 ± 0.126
7-S44-3.0	0.08 ± 0.03	1.00 ± 0.07	0.94 ± 0.07	2.1 ± 0.21	1.47 ± 0.147
7-S44-4.0	0.03 ± 0.02	1.42 ± 0.10	1.30 ± 0.09	1.9 ± 0.19	1.33 ± 0.133
7-S44-5.0	0.04 ± 0.02	1.26 ± 0.09	0.96 ± 0.07	1.8 ± 0.18	1.26 ± 0.126
7-S44-6.0	0.07 ± 0.03	1.14 ± 0.08	0.91 ± 0.07	2.0 ± 0.2	1.40 ± 0.14
7-S44-7.0	0.04 ± 0.02	1.61 ± 0.11	0.94 ± 0.07	1.9 ± 0.19	1.33 ± 0.133
7-S44-8.0	0.09 ± 0.03	1.16 ± 0.08	1.00 ± 0.07	1.8 ± 0.18	1.26 ± 0.126
7-S44-9.0	0.03 ± 0.02	1.09 ± 0.08	0.78 ± 0.05	1.7 ± 0.17	1.19 ± 0.119

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S45-1.0	0.06 ± 0.03	1.34 ± 0.09	1.59 ± 0.11	2.1 ± 0.2	1.4 ± 0.2
7-S45-2.0	<0.03	0.95 ± 0.07	0.98 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S45-3.0	0.04 ± 0.02	1.23 ± 0.09	0.78 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S45-4.0	<0.03	1.38 ± 0.10	1.30 ± 0.09	2.0 ± 0.2	1.4 ± 0.1
7-S45-5.0	0.09 ± 0.03	0.98 ± 0.07	1.17 ± 0.08	2.1 ± 0.2	1.4 ± 0.2
7-S45-6.0	0.12 ± 0.04	0.78 ± 0.07	0.78 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S45-7.0	<0.03	1.02 ± 0.07	1.19 ± 0.08	1.9 ± 0.2	1.3 ± 0.2
7-S45-8.0	0.04 ± 0.02	1.06 ± 0.07	0.99 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S45-9.0	<0.03	1.11 ± 0.08	0.83 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S45-10.0	0.04 ± 0.02	1.02 ± 0.07	0.82 ± 0.07	1.8 ± 0.2	1.2 ± 0.2
7-S46-1.0	0.15 ± 0.04	0.86 ± 0.07	0.84 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S46-2.0	<0.03	1.16 ± 0.08	1.29 ± 0.09	2.1 ± 0.2	1.4 ± 0.2
7-S46-3.0	<0.03	1.18 ± 0.08	1.10 ± 0.08	2.0 ± 0.2	1.4 ± 0.2
7-S46-4.0	0.06 ± 0.03	1.38 ± 0.10	0.86 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S46-5.0	<0.03	1.16 ± 0.08	1.01 ± 0.07	2.2 ± 0.2	1.5 ± 0.2
7-S46-6.0	<0.03	1.37 ± 0.10	1.23 ± 0.09	2.0 ± 0.2	1.4 ± 0.2
7-S46-7.0	<0.03	0.89 ± 0.07	1.13 ± 0.08	2.0 ± 0.2	1.4 ± 0.2
7-S46-8.0	<0.03	1.01 ± 0.07	1.06 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S46-9.0	<0.03	1.22 ± 0.09	1.46 ± 0.10	1.9 ± 0.2	1.3 ± 0.2
7-S46-10.0	<0.03	0.98 ± 0.07	1.24 ± 0.09	2.0 ± 0.2	1.4 ± 0.2
7-S47-1.0	<0.03	1.00 ± 0.07	0.91 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S47-2.0	0.04 ± 0.02	1.10 ± 0.08	0.94 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S47-3.0	<0.03	1.22 ± 0.09	1.32 ± 0.09	1.9 ± 0.2	1.3 ± 0.2
7-S47-4.0	<0.03	0.98 ± 0.07	0.94 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S47-5.0	0.08 ± 0.03	1.13 ± 0.08	0.76 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S47-6.0	0.09 ± 0.03	0.77 ± 0.05	0.74 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S47-7.0	<0.03	1.19 ± 0.85	1.36 ± 0.10	2.0 ± 0.2	1.4 ± 0.2
7-S47-8.0	<0.03	1.18 ± 0.08	1.17 ± 0.08	1.9 ± 0.2	1.3 ± 0.2
7-S47-9.0	0.06 ± 0.03	1.34 ± 0.09	0.94 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S47-10.0	<0.03	1.04 ± 0.07	1.19 ± 0.08	1.9 ± 0.2	1.3 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometri μg/g ± σ	pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S48-1.0	0.09 ± 0.03	1.70 ± 0.12	1.03 ± 0.07	2.3 ± 0.2	1.6 ± 0.2
7-S48-2.0	0.06 ± 0.03	0.87 ± 0.06	0.86 ± 0.07	2.6 ± 0.3	1.8 ± 0.2
7-S48-3.0	<0.03	1.21 ± 0.09	1.13 ± 0.08	2.2 ± 0.2	1.5 ± 0.2
7-S48-4.0	0.11 ± 0.03	1.26 ± 0.09	0.92 ± 0.07	2.2 ± 0.2	1.5 ± 0.2
7-S48-5.0	0.08 ± 0.03	1.68 ± 0.12	0.74 ± 0.07	2.7 ± 0.2	1.9 ± 0.2
7-S48-6.0	<0.03	1.33 ± 0.09	1.19 ± 0.08	2.2 ± 0.2	1.5 ± 0.2
7-S48-7.0	<0.03	1.39 ± 0.10	1.02 ± 0.07	2.2 ± 0.2	1.5 ± 0.2
7-S48-8.0	0.05 ± 0.03	1.57 ± 0.11	0.91 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S48-9.0	<0.03	1.32 ± 0.09	1.14 ± 0.08	1.9 ± 0.2	1.3 ± 0.2
7-S48-10.0	0.07 ± 0.03	1.09 ± 0.08	0.90 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S49-1.0	0.29 ± 0.04	0.92 ± 0.07	1.05 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S49-2.0	0.08 ± 0.03	1.37 ± 0.09	1.47 ± 0.10	2.0 ± 0.2	1.4 ± 0.2
7-S49-3.0	0.20 ± 0.06	1.25 ± 0.09	0.99 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S49-4.0	0.11 ± 0.05	1.70 ± 0.12	0.94 ± 0.07	2.3 ± 0.2	1.6 ± 0.2
7-S49-5.0	0.06 ± 0.03	1.77 ± 0.12	1.38 ± 0.10	2.1 ± 0.2	1.4 ± 0.2
7-S49-6.0	<0.03	1.11 ± 0.11	1.47 ± 0.10	2.2 ± 0.2	1.5 ± 0.2
7-S49-7.0	<0.03	1.62 ± 0.11	1.47 ± 0.10	2.2 ± 0.2	1.5 ± 0.2
7-S49-8.0	<0.03	1.45 ± 0.10	1.08 ± 0.08	2.0 ± 0.2	1.4 ± 0.2
7-S49-9.0	<0.03	1.33 ± 0.09	1.11 ± 0.08	2.0 ± 0.2	1.4 ± 0.2
7-S49-10.0	<0.03	1.30 ± 0.09	1.33 ± 0.09	2.0 ± 0.2	1.4 ± 0.2
7-S50-1.0	0.09 ± 0.05	0.98 ± 0.07	1.09 ± 0.08	2.1 ± 0.2	1.4 ± 0.2
7-S50-2.0	<0.03	0.91 ± 0.07	1.02 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S50-3.0	0.05 ± 0.02	1.19 ± 0.08	1.35 ± 0.09	2.0 ± 0.2	1.4 ± 0.2
7-S50-4.0	0.04 ± 0.02	0.97 ± 0.07	1.38 ± 0.10	2.2 ± 0.2	1.5 ± 0.2
7-S50-5.0	0.05 ± 0.02	1.06 ± 0.07	0.91 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S50-6.0	0.09 ± 0.04	0.91 ± 0.07	0.79 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S50-7.0	<0.03	1.53 ± 0.11	1.42 ± 0.10	2.2 ± 0.2	2.2 ± 0.2
7-S50-8.0	<0.03	1.27 ± 0.09	1.01 ± 0.07	3.2 ± 0.3	2.2 ± 0.2
7-S50-9.0	<0.03	0.95 ± 0.07	0.86 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S50-10.0	<0.03	1.11 ± 0.08	1.01 ± 0.07	1.8 ± 0.2	1.2 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	Uranium Fluorometric pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S51-1.0	0.36 ± 0.04	0.98 ± 0.07	0.82 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S51-2.0	<0.03	1.20 ± 0.08	1.27 ± 0.09	1.9 ± 0.2	1.3 ± 0.2
7-S51-3.0	0.06 ± 0.03	0.68 ± 0.07	0.77 ± 0.07	1.7 ± 0.2	1.2 ± 0.2
7-S51-4.0	<0.03	0.96 ± 0.07	1.26 ± 0.09	2.0 ± 0.2	1.4 ± 0.2
7-S51-5.0	<0.03	0.78 ± 0.07	0.92 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S51-6.0	<0.03	1.33 ± 0.09	1.11 ± 0.08	2.0 ± 0.2	1.4 ± 0.2
7-S51-7.0	0.05 ± 0.03	1.22 ± 0.09	1.30 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S51-8.0	<0.03	1.10 ± 0.08	1.27 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S51-9.0	<0.03	1.17 ± 0.08	1.03 ± 0.07	1.8 ± 0.2	1.2 ± 0.2
7-S51-10.0	<0.03	1.31 ± 0.09	1.29 ± 0.09	1.8 ± 0.2	1.2 ± 0.1
7-S52-1.0	<0.03	0.72 ± 0.07	1.05 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S52-2.0	0.04 ± 0.02	0.93 ± 0.07	0.95 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S52-3.0	<0.03	1.15 ± 0.08	1.40 ± 0.10	1.9 ± 0.2	1.3 ± 0.2
7-S52-4.0	<0.03	1.10 ± 0.08	1.27 ± 0.09	2.2 ± 0.2	1.5 ± 0.2
7-S52-5.0	<0.03	1.30 ± 0.09	0.76 ± 0.07	2.2 ± 0.2	1.5 ± 0.2
7-S52-6.0	<0.03	1.42 ± 0.10	1.32 ± 0.09	2.1 ± 0.2	1.4 ± 0.2
7-S52-7.0	<0.03	1.30 ± 0.09	0.99 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S52-8.0	<0.03	0.65 ± 0.12	1.53 ± 0.11	2.1 ± 0.2	1.4 ± 0.2
7-S52-9.0	<0.03	1.41 ± 0.10	1.20 ± 0.08	2.1 ± 0.2	1.4 ± 0.2
7-S52-10.0	0.13 ± 0.04	0.95 ± 0.07	0.71 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S53-1.0	0.32 ± 0.04	1.21 ± 0.08	1.00 ± 0.07	2.3 ± 0.2	1.6 ± 0.2
7-S53-2.0	<0.03	0.95 ± 0.07	0.88 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S53-3.0	<0.03	0.71 ± 0.07	1.25 ± 0.08	1.8 ± 0.2	1.2 ± 0.2
7-S53-4.0	<0.03	1.22 ± 0.09	1.30 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S53-5.0	<0.03	1.40 ± 0.10	0.77 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S53-6.0	<0.03	0.99 ± 0.07	1.06 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S53-7.0	<0.03	1.32 ± 0.09	1.31 ± 0.09	2.0 ± 0.2	1.4 ± 0.2
7-S53-8.0	<0.03	1.12 ± 0.08	0.97 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S53-9.0	<0.03	0.61 ± 0.07	0.67 ± 0.07	2.1 ± 0.2	1.4 ± 0.2
7-S53-10.0	0.05 ± 0.03	1.10 ± 0.08	0.96 ± 0.07	1.7 ± 0.2	1.2 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	Uranium Fluorometric pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S54-1.0	0.29 ± 0.04	1.15 ± 0.08	1.16 ± 0.08	2.6 ± 0.3	1.8 ± 0.2
7-S54-2.0	<0.03	1.15 ± 0.08	1.09 ± 0.08	2.3 ± 0.2	1.6 ± 0.2
7-S54-3.0	0.05 ± 0.03	1.42 ± 0.10	1.17 ± 0.08	2.1 ± 0.2	1.4 ± 0.2
7-S54-4.0	<0.03	1.43 ± 0.10	1.25 ± 0.09	2.0 ± 0.2	1.4 ± 0.2
7-S54-5.0	<0.03	1.06 ± 0.07	1.00 ± 0.07	1.8 ± 0.2	1.2 ± 0.2
7-S54-6.0	0.11 ± 0.03	0.81 ± 0.07	0.88 ± 0.07	1.8 ± 0.2	1.2 ± 0.2
7-S54-7.0	0.13 ± 0.03	1.20 ± 0.08	0.91 ± 0.07	1.9 ± 0.2	1.3 ± 0.2
7-S54-8.0	<0.03	1.03 ± 0.07	0.91 ± 0.07	2.0 ± 0.2	1.4 ± 0.2
7-S54-9.0	0.10 ± 0.03	0.98 ± 0.07	1.10 ± 0.08	1.9 ± 0.2	1.3 ± 0.2
7-S54-10.0	<0.03	1.12 ± 0.08	0.79 ± 0.07	1.7 ± 0.2	1.2 ± 0.2
7-S55-1.0	0.14 ± 0.04	1.32 ± 0.09	1.04 ± 0.07	2.5 ± 0.3	1.7 ± 0.2
7-S55-2.0	0.08 ± 0.03	1.25 ± 0.09	1.09 ± 0.08	3.0 ± 0.3	2.1 ± 0.2
7-S55-3.0	<0.03	1.12 ± 0.08	1.05 ± 0.07	2.4 ± 0.2	1.7 ± 0.2
7-S55-4.0	<0.03	0.91 ± 0.07	0.71 ± 0.07	2.2 ± 0.2	1.5 ± 0.2
7-S55-5.0	<0.03	1.18 ± 0.08	0.89 ± 0.05	1.8 ± 0.4	1.2 ± 0.2
7-S55-6.0	<0.03	1.10 ± 0.06	0.83 ± 0.05	2.0 ± 0.4	1.4 ± 0.2
7-S55-7.0	<0.03	1.00 ± 0.07	0.96 ± 0.06	1.7 ± 0.3	1.2 ± 0.2
7-S55-8.0	<0.03	1.18 ± 0.07	0.92 ± 0.05	2.2 ± 0.4	1.5 ± 0.2
7-S55-9.0	<0.03	0.95 ± 0.05	0.81 ± 0.05	1.4 ± 0.3	1.0 ± 0.2
7-S55-10.0	<0.03	1.11 ± 0.07	0.93 ± 0.05	1.7 ± 0.3	1.2 ± 0.2
7-S99-1.0	0.12 ± 0.04	2.26 ± 0.23	1.00 ± 0.10	2.1 ± 0.2	1.4 ± 0.2
7-S99-2.0	<0.03	1.01 ± 0.10	1.13 ± 0.11	1.6 ± 0.2	1.1 ± 0.2
7-S99-3.0	<0.03	1.10 ± 0.11	0.96 ± 0.10	1.7 ± 0.2	1.2 ± 0.2
7-S99-4.0	<0.03	1.05 ± 0.11	0.57 ± 0.06	1.8 ± 0.2	1.2 ± 0.2
7-S99-5.0	<0.03	1.21 ± 0.12	1.04 ± 0.10	1.6 ± 0.2	1.1 ± 0.2
7-S99-6.0	<0.03	1.05 ± 0.11	1.06 ± 0.11	1.4 ± 0.2	1.0 ± 0.2
7-S99-7.0	<0.03	1.27 ± 0.13	1.09 ± 0.11	1.4 ± 0.2	1.0 ± 0.2
7-S99-8.5	<0.03	1.20 ± 0.12	1.04 ± 0.10	1.4 ± 0.2	1.0 ± 0.2
7-S99-9.5	0.03 ± 0.2	1.07 ± 0.11	0.91 ± 0.09	1.3 ± 0.2	0.9 ± 0.2
7-S99-10.5	<0.03	0.98 ± 0.10	0.91 ± 0.09	1.4 ± 0.2	1.0 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S100-1.0	0.17 ± 0.05	3.10 ± 0.31	0.99 ± 0.10	1.8 ± 0.2	1.2 ± 0.2
7-S100-2.0	<0.03	1.03 ± 0.10	1.21 ± 0.12	1.7 ± 0.2	1.2 ± 0.2
7-S100-3.0	<0.03	0.97 ± 0.10	1.09 ± 0.11	1.7 ± 0.2	1.2 ± 0.2
7-S100-4.0	<0.03	1.36 ± 0.14	0.93 ± 0.09	1.6 ± 0.2	1.1 ± 0.2
7-S100-5.0	<0.03	1.50 ± 0.15	0.88 ± 0.09	1.6 ± 0.2	1.1 ± 0.2
7-S100-6.0	<0.03	1.07 ± 0.11	0.78 ± 0.08	1.5 ± 0.2	1.0 ± 0.2
7-S100-8.0	<0.03	1.35 ± 0.14	0.78 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S100-9.0	<0.03	0.92 ± 0.09	0.84 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S100-10.0	<0.03	1.06 ± 0.11	0.87 ± 0.09	1.6 ± 0.2	1.1 ± 0.2
7-S101-1	0.18 ± 0.05	21.0 ± 2.1	1.08 ± 0.11	1.7 ± 0.2	1.2 ± 0.2
7-S101-2	0.07 ± 0.04	1.83 ± 0.18	1.02 ± 0.10	1.7 ± 0.2	1.2 ± 0.2
7-S101-3	<0.03	1.44 ± 0.14	1.24 ± 0.12	1.7 ± 0.2	1.2 ± 0.2
7-S101-4	0.04 ± 0.02	1.30 ± 0.13	0.98 ± 0.10	1.5 ± 0.2	1.0 ± 0.2
7-S101-5	<0.03	1.29 ± 0.13	0.95 ± 0.10	1.5 ± 0.2	1.0 ± 0.2
7-S101-6	<0.03	1.31 ± 0.13	1.22 ± 0.12	1.3 ± 0.2	0.9 ± 0.2
7-S101-7	<0.03	1.29 ± 0.13	0.94 ± 0.09	1.4 ± 0.2	1.0 ± 0.2
7-S101-8	<0.03	0.98 ± 0.09	0.88 ± 0.09	1.4 ± 0.2	1.0 ± 0.2
7-S101-9	BDL[a]	1.10 ± 0.11	0.69 ± 0.07	1.4 ± 0.2	1.0 ± 0.2
7-S101-10	BDL	0.77 ± 0.08	0.58 ± 0.06	1.4 ± 0.2	1.0 ± 0.2
7-S102-1	0.16 ± 0.13	1.32 ± 0.13	0.88 ± 0.09	1.7 ± 0.2	1.2 ± 0.2
7-S102-2	BDL	1.21 ± 0.11	0.86 ± 0.09	1.6 ± 0.2	1.1 ± 0.2
7-S102-3	BDL	1.39 ± 0.14	0.92 ± 0.09	1.7 ± 0.2	1.2 ± 0.2
7-S102-4	0.11 ± 0.03	1.21 ± 0.12	0.93 ± 0.09	1.5 ± 0.2	1.0 ± 0.2
7-S102-5	BDL	1.51 ± 0.15	0.83 ± 0.08	1.5 ± 0.2	1.0 ± 0.2
7-S102-6	BDL	1.49 ± 0.15	1.05 ± 0.10	1.3 ± 0.2	0.9 ± 0.2
7-S102-7	<0.03	1.17 ± 0.12	1.03 ± 0.10	1.5 ± 0.2	1.0 ± 0.2
7-S102-8	<0.03	0.94 ± 0.09	0.86 ± 0.09	1.4 ± 0.2	1.0 ± 0.2
7-S102-9	<0.03	0.94 ± 0.09	0.83 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S102-10	<0.03	1.13 ± 0.11	0.68 ± 0.07	1.3 ± 0.2	0.9 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorome μg/g ± σ	pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S103-1	0.29 ± 0.04	23.4 ± 2.3	0.82 ± 0.08	1.8 ± 0.2	1.2 ± 0.2
7-S103-2	<0.03	1.16 ± 0.12	1.19 ± 0.12	1.5 ± 0.2	1.0 ± 0.2
7-S103-3	<0.03	1.32 ± 0.13	0.96 ± 0.10	1.6 ± 0.2	1.1 ± 0.2
7-S103-4	<0.03	0.95 ± 0.10	0.88 ± 0.09	1.6 ± 0.2	1.1 ± 0.2
7-S103-5	<0.03	0.91 ± 0.10	0.94 ± 0.09	1.6 ± 0.2	1.1 ± 0.2
7-S103-6	<0.03	1.16 ± 0.11	0.77 ± 0.08	1.5 ± 0.2	1.0 ± 0.2
7-S103-7	<0.03	1.62 ± 0.16	0.79 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S103-8	<0.03	1.42 ± 0.14	0.97 ± 0.10	1.5 ± 0.2	1.0 ± 0.2
7-S103-9	<0.03	0.75 ± 0.08	0.91 ± 0.09	1.4 ± 0.2	1.0 ± 0.2
7-S103-10	<0.03	1.14 ± 0.11	0.68 ± 0.07	1.4 ± 0.2	1.0 ± 0.2
7-S104-1	0.19 ± 0.06	2.98 ± 0.30	1.11 ± 0.11	1.6 ± 0.2	1.1 ± 0.2
7-S104-2	<0.03	1.40 ± 0.14	0.94 ± 0.09	1.6 ± 0.2	1.1 ± 0.2
7-S104-3	<0.03	1.22 ± 0.12	0.67 ± 0.07	1.6 ± 0.2	1.1 ± 0.2
7-S104-4	<0.03	1.03 ± 0.10	0.97 ± 0.10	1.5 ± 0.2	1.0 ± 0.2
7-S104-5	BDL	1.20 ± 0.12	0.73 ± 0.07	1.4 ± 0.2	1.0 ± 0.2
7-S104-6	BDL	1.48 ± 0.15	1.07 ± 0.11	1.5 ± 0.2	1.0 ± 0.2
7-S104-7	BDL	1.31 ± 0.13	0.85 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S104-8	BDL	0.98 ± 0.10	0.18 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S104-9	BDL	1.00 ± 0.10	0.78 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S104-10	<0.03	1.01 ± 0.10	0.97 ± 0.10	1.4 ± 0.2	1.0 ± 0.2
7-S105-1	0.26 ± 0.04	1.11 ± 0.11	0.73 ± 0.07	1.8 ± 0.2	1.2 ± 0.2
7-S105-2	<0.03	1.14 ± 0.11	0.90 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S105-3	0.08 ± 0.03	1.05 ± 0.11	0.94 ± 0.09	1.7 ± 0.2	1.2 ± 0.2
7-S105-5	<0.03	1.08 ± 0.11	1.07 ± 0.11	1.5 ± 0.2	1.0 ± 0.2
7-S105-6	<0.03	1.23 ± 0.12	0.84 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S105-7	<0.03	1.32 ± 0.13	0.89 ± 0.09	1.3 ± 0.2	0.9 ± 0.2
7-S105-8	<0.03	1.15 ± 0.12	0.68 ± 0.07	1.3 ± 0.2	0.9 1 0.2
7-S105-9	<0.03	1.33 ± 0.13	1.03 ± 0.10	1.3 ± 0.2	0.9 ± 0.2
7-S105-10	<0.03	1.37 ± 0.14	0.79 ± 0.08	1.3 ± 0.2	0.9 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226} Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S106-1	0.22 ± 0.04	1.01 ± 0.10	0.89 ± 0.09	1.7 ± 0.2	1.2 ± 0.2
7-S106-2	0.23 ± 0.04	1.05 ± 0.10	0.92 ± 0.09	1.6 ± 0.2	1.1 ± 0.2
7-S106-3	<0.03	0.68 ± 0.07	0.82 ± 0.08	1.8 ± 0.2	1.2 ± 0.2
7-S106-4	<0.03	0.94 ± 0.09	1.12 ± 0.11	1.5 ± 0.2	1.0 ± 0.2
7-S106-5	BDL	1.18 ± 0.12	0.87 ± 0.09	1.4 ± 0.2	1.0 ± 0.2
7-S106-6	BDL	1.10 ± 0.11	0.77 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S106-7	BDL	1.34 ± 0.13	0.73 ± 0.07	1.4 ± 0.2	1.0 ± 0.2
7-S106-8	BDL	1.37 ± 0.14	1.08 ± 0.11	1.4 ± 0.2	1.0 ± 0.2
7-S106-9	BDL	1.30 ± 0.13	1.04 ± 0.10	1.4 ± 0.2	1.0 ± 0.2
7-S106-10	BDL	1.06 ± 0.11	0.78 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S107-1	0.32 ± 0.05	0.99 ± 0.10	0.78 ± 0.08	1.8 ± 0.2	1.2 ± 0.2
7-S107-2	<0.03	1.01 ± 0.10	0.97 ± 0.10	1.7 ± 0.2	1.2 ± 0.2
7-S107-3	0.07 ± 0.04	1.12 ± 0.11	0.92 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S107-4	<0.03	1.03 ± 0.10	1.06 ± 0.11	1.5 ± 0.2	1.0 ± 0.2
7-S107-5	<0.03	1.34 ± 0.13	0.70 ± 0.07	1.5 ± 0.2	1.0 ± 0.2
7-S107-6	<0.03	1.15 ± 0.12	0.85 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S107-7	BDL	1.06 ± 0.11	1.12 ± 0.11	1.4 ± 0.2	1.0 ± 0.2
7-S107-8	<0.03	1.23 ± 0.12	0.88 ± 0.09	1.5 ± 0.2	1.0 ± 0.2
7-S107-9	<0.03	1.24 ± 0.12	0.81 ± 0.08	1.4 ± 0.2	1.0 ± 0.2
7-S107-10	<0.03	0.95 ± 0.10	0.80 ± 0.08	1.3 ± 0.2	0.9 ± 0.2
7-S108-1	0.33 ± 0.05	0.99 ± 0.10	1.02 ± 0.10	1.9 ± 0.2	1.3 ± 0.2
7-S108-2	0.07 1 0.04	0.89 ± 0.09	1.07 ± 0.11	1.7 ± 0.2	1.2 ± 0.2
7-S108-3	0.06 ± 0.03	1.02 ± 0.10	0.89 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S108-4	<0.03	1.25 ± 0.12	1.00 ± 0.10	1.5 ± 0.2	1.0 ± 0.2
7-S108-5	<0.03	0.99 ± 0.10	0.90 ± 0.09	1.5 ± 0.2	1.0 ± 0.2
7-S108-6	BDL	0.79 ± 0.08	0.74 ± 0.07	1.8 ± 0.2	1.2 ± 0.2
7-S108-7	BDL	1.15 ± 0.12	0.92 ± 0.09	1.4 ± 0.2	1.0 ± 0.2
7-S108-8	BDL	1.31 ± 0.13	0.72 ± 0.07	1.5 ± 0.1	1.0 ± 0.2
7-S108-9	BDL	0.92 ± 0.09	0.81 ± 0.08	1.5 ± 0.2	1.0 ± 0.2
7-S108-10	<0.03	0.71 ± 0.07	0.22 ± 0.02	1.5 ± 0.2	1.0 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	Uranium Fluorometric pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S109-1	0.25 ± 0.04	11.80 ± 1.20	0.98 ± 0.10	1.9 ± 0.2	1.3 ± 0.2
7-S109-2	<0.03	1.92 ± 0.19	1.13 ± 0.11	1.8 ± 0.2	1.2 ± 0.2
7-S109-3	<0.03	1.72 ± 0.17	0.86 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S109-4	<0.03	1.40 ± 0.14	0.92 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S109-5	<0.03	1.08 ± 0.11	0.94 ± 0.09	1.7 ± 0.2	1.2 ± 0.2
7-S109-6	<0.03	1.17 ± 0.12	0.80 ± 0.08	1.6 ± 0.2	1.1 ± 0.2
7-S109-7	<0.03	1.45 ± 0.14	0.81 ± 0.08	1.5 ± 0.2	1.0 ± 0.2
7-S109-8	<0.03	1.47 ± 0.15	0.98 ± 0.10	1.5 ± 0.2	1.0 ± 0.2
7-S109-9	<0.03	1.57 ± 0.16	0.92 ± 0.09	1.5 ± 0.2	1.0 ± 0.2
7-S109-10	<0.03	1.18 ± 0.12	0.90 ± 0.09	1.4 ± 0.2	1.0 ± 0.2
7-S110-1	0.14 ± 0.04	6.18 ± 0.62	1.00 ± 0.10	2.2 ± 0.2	1.5 ± 0.2
7-S110-2	0.06 ± 0.03	2.71 ± 0.27	0.70 ± 0.07	1.8 ± 0.2	1.2 ± 0.2
7-S110-3	<0.03	1.10 ± 0.11	1.09 ± 0.11	1.7 ± 0.2	1.2 ± 0.2
7-S110-4	<0.03	0.89 ± 0.09	0.88 ± 0.09	1.8 ± 0.2	1.2 ± 0.2
7-S110-5	<0.03	1.05 ± 0.10	0.96 ± 0.10	1.7 ± 0.2	1.2 ± 0.2
7-S110-6	<0.03	1.36 ± 0.14	0.82 ± 0.08	1.6 ± 0.2	1.1 ± 0.2
7-S110-7	BDL	0.73 ± 0.07	1.02 ± 0.10	1.7 ± 0.2	1.2 ± 0.2
7-S110-8	<0.03	1.15 ± 0.12	1.22 ± 0.12	1.5 ± 0.2	1.0 ± 0.2
7-S110-9	<0.03	0.95 ± 0.10	0.95 ± 0.09	1.4 ± 0.2	1.0 ± 0.2
7-S110-10	<0.03	1.28 ± 0.13	0.94 ± 0.06	1.5 ± 0.2	1.0 ± 0.2
7-S111-1	0.98 ± 0.10	21.9 ± 2.2	0.62 ± 0.06	13.2 ± 1.3	9.1 ± 0.9
7-S111-2	0.13 ± 0.04	2.74 ± 0.27	<0.02	4.3 ± 0.4	3.0 ± 0.3
7-S111-3	<0.03	1.02 ± 0.10	0.75 ± 0.08	1.6 ± 0.2	1.1 ± 0.2
7-S111-4	BDL	0.81 ± 0.08	0.72 ± 0.07	1.7 ± 0.2	1.2 ± 0.2
7-S111-5	BDL	0.82 ± 0.08	0.70 ± 0.07	1.6 ± 0.2	1.1 ± 0.2
7-S111-6	BDL	0.60 ± 0.06	0.51 ± 0.05	1.3 ± 0.2	0.9 ± 0.2
7-S111-7	<0.03	0.62 ± 0.06	0.36 ± 0.04	1.1 ± 0.2	0.8 ± 0.2
7-S111-8	0.09 ± 0.04	0.48 ± 0.05	0.90 ± 0.09	1.2 ± 0.2	0.8 ± 0.2
7-S111-9	<0.03	0.33 ± 0.03	0.34 ± 0.03	1.0 ± 0.2	0.7 ± 0.2
7-S111-10	<0.03	0.32 ± 0.03	0.44 ± 0.04	1.0 ± 0.2	0.7 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ			Uranium Fluorometric	
	^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	μg/g ± σ	pCi/g ± σ
		SOIL BORINGS - (cont'd.)			
7-S112-1	0.29 1 0.04	1.03 ± 0.10	0.77 ± 0.08	3.2 ± 0.3	2.2 ± 0.2
7-S112-3	<0.03	ND[b]	0.66 ± 0.07	1.8 ± 0.2	1.2 ± 0.2
7-S112-4	<0.03	0.81 ± 0.08	0.65 ± 0.06	1.6 ± 0.2	1.1 ± 0.2
7-S112-5	<0.03	0.80 ± 0.08	0.72 ± 0.07	1.7 ± 0.2	1.2 ± 0.2
7-S112- 6	<0.03	0.57 ± 0.06	0.46 ± 0.05	1.1 ± 0.2	0.8 ± 0.2
7-S112-7	<0.03	ND	0.50 ± 0.05	1.0 ± 0.2	0.7 ± 0.2
7-S112-8	<0.03	0.51 ± 0.05	0.34 ± 0.03	1.1 ± 0.2	0.8 ± 0.2
7-S112-9	<0.03	ND	0.38 ± 0.04	0.9 ± 0.2	0.6 ± 0.2
7-S112-10	<0.03	ND	0.30 ± 0.03	0.9 ± 0.2	0.6 ± 0.2
7-S113-1	0.38 ± 0.04	10.6 ± 1.10	0.91 ± 0.09	2.4 ± 0.3	1.6 ± 0.2
7-S113-2	<0.03	2.17± 0.22	1.16 ± 0.12	1.6 ± 0.2	1.1 ± 0.1
7-S113-3	<0.03	0.68± 0.07	0.58 ± 0.06	1.5 ± 0.2	1.0 ± 0.1
7-S113-4	<0.03	0.82± 0.08	0.78 ± 0.08	1.5 ± 0.2	1.0 ± 0.1
7-S113-5	<0.03	0.55± 0.08	0.77 ± 0.08	1.6 ± 0.2	1.1 ± 0.1
7-S113-6	<0.03	0.87± 0.09	0.48 ± 0.05	1.2 ± 0.1	0.8 ± 0.1
7-S113-7	<0.03	0.37± 0.07	0.29 ± 0.03	1.0 ± 0.1	0.7 ± 0.1
7-S113-8	0.06 ± 0.03	0.20± 0.06	0.42 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S113-9	BDL	0.44± 0.07	0.36 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S113-10	<0.03	0.53± 0.08	0.38 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S114-1	0.28 ± 0.04	1.14± 0.11	0.75 ± 0.08	1.9 ± 0.2	1.3 ± 0.1
7-S114-2	BDL	1.11± 0.11	0.76 ± 0.08	1.7 ± 0.2	1.2 ± 0.1
7-S114-3	BDL	0.99± 0.10	0.57 ± 0.06	1.6 ± 0.2	1.1 ± 0.1
7-S114-4	BDL	0.63± 0.06	0.42 ± 0.04	1.6 ± 0.1	1.1 ± 0.1
7-S114-5	BDL	0.72± 0.07	0.36 ± 0.04	1.4 ± 0.1	1.0 ± 0.1
7-S114-6	<0.03	0.32± 0.06	0.49 ± 0.05	1.1 ± 0.1	0.8 ± 0.1
7-S114-7	<0.03	0.21± 0.06	0.50 ± 0.05	1.1 ± 0.1	0.8 ± 0.1
7-S114-8	<0.03	ND	0.46 ± 0.05	1.0 ± 0.1	0.7 ± 0.1
7-S114-9	0.05 ± 0.02	0.30± 0.09	0.43 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S114-10	BDL	0.24± 0.07	0.54 ± 0.05	1.0 ± 0.1	0.7 ± 0.1

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
7-S115-1	0.13 ± 0.04	1.16± 0.12	0.88 ± 0.09	1.9 ± 0.2	1.3 ± 0.1
7-S115-2	<0.03	1.57± 0.16	0.75 ± 0.08	1.6 ± 0.2	1.1 ± 0.1
7-S115-3	<0.03	0.62± 0.06	0.62 ± 0.06	1.5 ± 0.2	1.0 ± 0.1
7-S115-4	<0.03	1.07± 0.11	0.57 ± 0.06	1.6 ± 0.2	1.1 ± 0.1
7-S115-5	<0.03	0.50± 0.08	0.45 ± 0.04	1.1 ± 0.1	0.8 ± 0.1
7-S115-6	<0.03	0.85± 0.08	0.33 ± 0.03	1.1 ± 0.1	0.8 ± 0.1
7-S115-7	<0.03	0.69± 0.07	0.34 ± 0.03	0.9 ± 0.1	0.6 ± 0.1
7-S115-8	<0.03	ND	0.64 ± 0.06	0.9 ± 0.1	0.6 ± 0.1
7-S115-9	<0.03	0.14± 0.06	0.58 ± 0.06	0.9 ± 0.1	0.6 ± 0.1
7-S115-10	<0.03	0.48± 0.07	0.38 ± 0.04	0.9 ± 0.1	0.6 ± 0.1
7-S116-1	0.50 ± 0.05	44.5 ± 4.4	0.88 ± 0.09	4.1 ± 0.4	2.8 ± 0.3
7-S116-2	<0.03	5.17± 0.52	0.84 ± 0.08	2.2 ± 0.2	1.5 ± 0.2
7-S116-3	0.05 ± 0.03	4.76± 0.48	0.78 ± 0.08	1.8 ± 0.2	1.2 ± 0.1
7-S117-1	2.50 ± 0.25	1.52± 0.15	0.88 ± 0.09	3.9 ± 0.4	2.7 ± 0.3
7-S117-2	1.00 ± 0.10	2.20± 0.22	0.60 ± 0.06	2.2 ± 0.2	1.5 ± 0.2
7-S117-3	0.50 ± 0.05	0.83± 0.08	0.94 ± 0.09	2.0 ± 0.2	1.4 ± 0.2
7-S118-1	2.86 ± 0.29	2.02± 0.20	0.89 ± 0.09	3.8 ± 0.4	2.6 ± 0.3
7-S118-2	<0.03	0.79± 0.08	0.47 ± 0.05	1.8 ± 0.2	1.2 ± 0.1
7-S119-1	0.25 ± 0.05	1.80± 0.18	0.94 ± 0.09	4.2 ± 0.4	2.9 ± 0.3
7-S119-2	1.54 ± 0.15	3.13± 0.31	1.03 ± 0.10	4.2 ± 0.4	2.9 ± 0.3
7-S120-1	1.28 ± 0.13	9.83± 0.98	0.27 ± 0.03	3.0 ± 0.3	2.0 ± 0.2
7-S120-2	0.18 ± 0.03	2.06± 0.21	0.61 ± 0.06	1.2 ± 0.1	0.8 ± 0.1
7-S120-3	0.20 ± 0.03	2.71± 0.27	0.46 ± 0.05	1.2 ± 0.1	0.8 ± 0.1
7-S121-1	3.26 ± 0.33	20.8 ± 2.1	2.86 ± 0.29	12.5 ± 1.3	8.6 ± 0.9
7-S121-2	3.02 ± 0.30	6.24± 0.62	0.93 ± 0.09	3.5 ± 0.4	2.4 ± 0.3
7-S121-3	1.11 ± 0.11	5.53± 0.55	1.40 ± 0.14	3.2 ± 0.3	2.2 ± 0.2

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ			Uranium Fluorometric	
	^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	μg/g ± σ	pCi/g ± σ
7-S122-1	0.10 ±0.04	1.24± 0.12	0.97 ± 0.10	1.9 ± 0.2	1.3 ± 0.1
7-S122-2	0.12 ±0.04	0.91± 0.09	1.08 ± 0.11	1.8 ± 0.2	1.2 ± 0.1
7-S122-3	0.09 ±0.04	1.09± 0.11	0.56 ± 0.06	1.6 ± 0.2	1.1 ± 0.1
7-S122-4	<0.03	0.69± 0.07	0.70 ± 0.07	1.5 ± 0.2	1.0 ± 0.1
7-S122-5	<0.03	0.71± 0.07	0.57 ± 0.06	1.3 ± 0.1	0.9 ± 0.1
7-S122-6	BDL	0.36± 0.07	0.21 ± 0.03	1.1 ± 0.1	0.8 ± 0.1
7-S122-7	BDL	0.42± 0.08	0.33 ± 0.03	0.9 ± 0.1	0.6 ± 0.1
7-S122-8	BDL	0.43± 0.08	0.31 ± 0.03	1.0 ± 0.1	0.7 ± 0.1
7-S122-9	<0.03	0.73± 0.07	0.50 ± 0.05	1.1 ± 0.1	0.8 ± 0.1
7-S122-10	BDL	0.54± 0.08	0.14 ± 0.03	1.2 ± 0.1	0.8 ± 0.1
7-S123-1	3.46 ±0.35	101.0 ±10	1.63 ± 0.16	16.4 ± 1.6	11.3 ± 1.1
7-S123-2	0.05 ±0.02	2.80± 0.28	1.01 ± 0.10	2.0 ± 0.2	1.4 ± 0.2
7-S123-3	0.06 ±0.03	1.44± 0.14	0.81 ± 0.08	1.7 ± 0.2	1.2 ± 0.1
7-S123-4	0.06 ±0.03	1.07± 0.11	0.68 ± 0.07	1.5 ± 0.2	1.0 ± 0.1
7-S123-5	0.07 ±0.04	1.22± 0.12	0.75 ± 0.08	1.5 ± 0.2	1.0 ± 0.1
7-S123-6	<0.03	0.76± 0.08	0.25 ± 0.02	1.2 ± 0.1	0.8 ± 0.1
7-S123-7	<0.03	0.80± 0.08	0.48 ± 0.05	1.1 ± 0.1	0.8 ± 0.1
7-S123-8	<0.03	0.29± 0.09	0.54 ± 0.05	1.0 ± 0.1	0.7 ± 0.1
7-S123-9	<0.03	0.54± 0.08	0.44 ± 0.04	1.1 ± 0.1	0.8 ± 0.1
7-S123-10	<0.03	ND	0.33 ± 0.03	0.9 ± 0.1	0.6 ± 0.1
7-S124-1	0.04 ±0.04	2.64± 0.26	0.49 ± 0.05	1.6 ± 0.2	1.1 ± 0.1
7-S124-2	BDL	0.47± 0.07	0.81 ± 0.08	2.3 ± 0.2	1.6 ± 0.2
7-S124-3	BDL	0.78± 0.08	0.77 ± 0.08	1.9 ± 0.2	1.3 ± 0.1
7-S124-4	BDL	0.77± 0.08	0.77 ± 0.08	1.4 ± 0.2	1.0 ± 0.1
7-S124-5	<0.03	0.95± 0.10	0.46 ± 0.05	1.4 ± 0.2	1.0 ± 0.1
7-S124-6	<0.03	0.76± 0.08	0.37 ± 0.04	1.2 ± 0.1	0.8 ± 0.1
7-S124-7	<0.03	0.40± 0.08	0.46 ± 0.05	1.1 ± 0.1	0.8 ± 0.1
7-S124-8	<0.03	0.44± 0.07	0.50 ± 0.05	1.1 ± 0.1	0.8 ± 0.1
7-S124-9	<0.03	0.50± 0.08	0.52 ± 0.05	1.1 ± 0.1	0.8 ± 0.1
7-S124-10	<0.03	0.48± 0.07	0.56 ± 0.06	1.0 ± 0.1	0.7 ± 0.1

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric μg/g ± σ	pCi/g ± σ
7-S125-1	0.43 ± 0.04	3.75± 0.38	0.42 ± 0.04	3.4 ± 0.4	2.3 ± 0.2
7-S125-2	0.07 ± 0.04	0.56± 0.08	0.66 ± 0.07	2.4 ± 0.3	1.6 ± 0.2
7-S125-3	0.05 ± 0.02	0.40± 0.08	0.80 ± 0.08	1.7 ± 0.2	1.2 ± 0.1
7-S125-4	BDL	0.24± 0.07	0.84 ± 0.08	3.1 ± 0.3	2.1 ± 0.2
7-S125-5	<0.03	0.71± 0.07	0.48 ± 0.05	1.8 ± 0.2	1.2 ± 0.1
7-S125-6	<0.03	0.84± 0.08	0.29 ± 0.03	1.1 ± 0.1	0.8 ± 0.1
7-S125-7	<0.03	ND	0.48 ± 0.05	1.2 ± 0.1	0.8 ± 0.1
7-S125-8	<0.08	0.45± 0.07	0.93 ± 0.09	1.0 ± 0.1	0.7 ± 0.1
7-S125-9	<0.03	ND	0.41 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S125-10	<0.03	0.65± 0.06	0.43 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S126-1	0.33 ± 0.05	2.98± 0.30	0.67 ± 0.07	1.8 ± 0.2	1.2 ± 0.1
7-S126-2	0.03 ± 0.02	1.18± 0.12	0.64 ± 0.06	1.5 ± 0.2	1.0 ± 0.1
7-S126-3	0.05 ± 0.01	0.63± 0.06	0.64 ± 0.06	1.5 ± 0.2	1.0 ± 0.1
7-S126-4	<0.03	0.46± 0.07	0.34 ± 0.03	1.2 ± 0.1	0.8 ± 0.1
7-S126-5	<0.03	0.40± 0.08	0.38 ± 0.04	1.1 ± 0.1	0.8 ± 0.1
7-S126-6	<0.03	0.94± 0.09	0.11 ± 0.03	1.1 ± 0.1	0.8 ± 0.1
7-S126-7	<0.03	0.33± 0.10	0.51 ± 0.05	0.9 ± 0.1	0.6 ± 0.1
7-S126-8	<0.03	0.67± 0.07	0.38 ± 0.04	1.1 ± 0.1	0.8 ± 0.1
7-S126-9	< 0.03	0.48± 0.07	0.40 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S126-10	<0.03	0.58± 0.09	0.32 ± 0.03	1.1 ± 0.1	0.8 ± 0.1
7-S127-1	0.16 ± 0.03	0.90± 0.09	0.64 ± 0.06	2.2 ± 0.2	1.5 ± 0.2
7-S127-2	0.08 ± 0.02	0.54± 0.05	0.74 ± 0.07	1.6 ± 0.2	1.1 ± 0.1
7-S127-3	<0.03	0.58± 0.09	0.72 ± 0.07	1.4 ± 0.2	1.0 ± 0.1
7-S127-4	0.07 ± 0.04	0.65± 0.06	0.89 ± 0.09	1.6 ± 0.2	1.1 ± 0.1
7-S127-5	0.04 ± 0.02	0.48± 0.07	0.55 ± 0.06	1.3 ± 0.1	0.9 ± 0.1
7-S127-6	<0.06	ND	0.38 ± 0.04	1.1 ± 0.1	0.8 ± 0.1
7-S127-7	<0.03	0.11± 0.04	0.45 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S127-8	<0.03	0.43± 0.09	0.38 ± 0.04	0.8 ± 0.1	0.5 ± 0.1
7-S127-9	<0.03	0.42± 0.09	0.66 ± 0.07	0.9 ± 0.1	0.6 ± 0.1
7-S127-10	<0.03	0.34± 0.10	0.29 ± 0.03	0.9 ± 0.1	0.6 ± 0.1

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

	Ge(Li) Spectra, pCi/g±σ			Uranium Fluorometric	
Sample No.	^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	μg/g ± σ	pCi/g ± σ
7-S128-1	0.28 ±0.04	416.0 ±42.0	1.64 ± 0.16	1.9 ± 0.2	1.3 ± 0.1
7-S128-2	<0.03	43.1 ± 4.3	0.74 ± 0.07	1.5 ± 0.2	1.0 ± 0.1
7-S128-3	<0.03	6.81± 0.68	0.67 ± 0.07	1.5 ± 0.2	1.0 ± 0.1
7-S128-4	<0.03	1.23± 0.12	0.52 ± 0.05	1.4 ± 0.2	1.0 ± 0.1
7-S128-5	<0.03	1.60± 0.16	ND	1.1 ± 0.1	0.8 ± 0.1
7-S128-6	<0.03	0.48± 0.07	0.32 ± 0.03	1.1 ± 0.1	0.8 ± 0.1
7-S128-7	<0.03	1.04± 0.10	0.42 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S128-8	<0.03	ND	0.56 ± 0.06	1.0 ± 0.1	0.7 ± 0.1
7-S128-9	<0.03	0.40± 0.08	0.44 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S128-10	BDL	0.87± 0.09	0.32 ± 0.03	1.0 ± 0.1	0.7 ± 0.1
7-S129-1	0.20 ±0.06	1.91± 0.19	0.74 ± 0.07	1.7 ± 0.2	1.2 ± 0.1
7-S129-2	0.10 ±0.04	1.05± 0.10	0.65 ± 0.06	1.5 ± 0.2	1.0 ± 0.1
7-S129-3	BDL	1.02± 0.10	0.66 ± 0.07	1.5 ± 0.2	1.0 ± 0.1
7-S129-4	BDL	ND	0.40 ± 0.04	1.2 ± 0.1	0.8 ± 0.1
7-S129-5	BDL	0.44± 0.07	0.20 ± 0.02	0.9 ± 0.1	0.6 ± 0.1
7-S129-6	BDL	0.48± 0.07	0.20 ± 0.02	0.8 ± 0.1	0.5 ± 0.1
7-S129-7	<0.03	ND	0.37 ± 0.04	1.0 ± 0.1	0.7 ± 0.1
7-S129-8	<0.03	0.56± 0.08	0.37 ± 0.04	1.1 ± 0.1	0.8 ± 0.1
7-S129-9	<0.03	0.35± 0.07	0.51 ± 0.05	1.1 ± 0.1	0.8 ± 0.1
7-S129-10	<0.03	0.29± 0.03	0.48 ± 0.05	1.0 ± 0.1	0.7 ± 0.1
7-S130-1	0.14 ±0.04	2.72± 0.27	0.44 ± 0.04	2.1 ± 0.1	1.4 ± 0.1
7-S130-2	0.08 ±0.04	2.34± 0.23	0.59 ± 0.06	1.9 ± 0.2	1.3 ± 0.1
7-S130-3	<0.03	1.00 ± 0.10	0.68 ± 0.07	2.0 ± 0.2	1.4 ± 0.1
7-S130-4	<0.03	0.48± 0.07	0.40 ± 0.04	1.2 ± 0.1	0.8 ± 0.1
7-S130-5	<0.03	ND	0.38 ± 0.04	1.4 ± 0.1	1.0 ± 0.1
7-S130-6	<0.03	0.50± 0.08	0.52 ± 0.05	1.3 ± 0.1	0.9 ± 0.1
7-S130-7	<0.03	<0.06	<0.02	0.9 ± 0.1	0.6 ± 0.1
7-S130-8	<0.03	0.36± 0.07	0.13 ± 0.04	0.9 ± 0.1	0.6 ± 0.1
7-S130-9	<0.03	ND	0.19 ± 0.04	0.8 ± 0.1	0.5 ± 0.1
7-S130-10	<0.03	0.40± 0.08	0.26 ± 0.03	0.9 ± 0.1	0.6 ± 0.1

TABLE 5
(cont'd.)

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample No.	Ge(Li) Spectra, pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric µg/g ± σ	Uranium Fluorometric pCi/g ± σ
7-S131-1	0.20 ± 0.06	1.06± 0.11	0.78 ± 0.08	1.6 ± 0.1	1.1 ± 0.1
7-S131-2	<0.03	0.79± 0.08	0.60 ± 0.06	1.5 ± 0.2	1.0 ± 0.1
7-S131-3	<0.03	0.67± 0.07	0.76 ± 0.08	1.7 ± 0.2	1.2 ± 0.1
7-S131-4	<0.03	0.51± 0.08	0.30 ± 0.03	1.2 ± 0.1	0.8 ± 0.1
7-S131-5	<0.03	0.54± 0.08	0.40 ± 0.04	1.1 ± 0.1	0.8 ± 0.1
7-S131-6	<0.03	0.30± 0.09	0.41 ± 0.04	0.9 ± 0.1	0.6 ± 0.1
7-S131-7	<0.03	0.23± 0.07	0.32 ± 0.03	0.8 ± 0.1	0.5 ± 0.1
7-S131-8	<0.03	ND	0.34 ± 0.03	0.9 ± 0.1	0.6 ± 0.1
7-S131-9	<0.03	0.49± 0.07	0.49 ± 0.05	1.0 ± 0.1	0.7 ± 0.1
7-S131-10	<0.03	0.43± 0.09	0.38 ± 0.04	0.9 ± 0.1	0.6 ± 0.1

[a]BDL - Below Detectable Limits

[b]ND - Not detectable in this analysis.

NOTE: These results are to be compared with the pertinent guidelines identified in Appendix 6.

TABLE 6

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
		BACKGROUND SOIL CORINGS		
7-SB-1A	470.8	389.5	368.0	0.0
7-SB-1B	589.4	509.2	458.5	12.0
7-SB-1C	660.5	577.5	520.0	39.0
7-SB-1D	1559.5	1362.8	905.5	436.5
7-SB-2A	575.3	467.6	419.5	32.0
7-SB-2B	551.5	468.5	422.2	17.0
7-SB-2C	767.1	658.3	622.2	13.2
7-SB-2D	1891.2	1602.6	1132.4	459.0
7-SB-3A	463.0	374.3	346.5	12.0
7-SB-3B	564.7	476.1	384.0	31.0
7-SB-3C	794.7	683.4	567.4	107.8
7-SB-3D	2160.0	1835.0	1258.0	559.5
7-SB-4A	570.4	500.7	468.0	16.0
7-SB-4B	617.7	535.9	509.0	9.0
7-SB-4C	625.8	549.6	480.5	43.0
7-SB-4D	1883.0	1617.9	1283.0	324.5
		SOIL CORINGS		
7-S-5A	470.6	365.8	258.0	104.5
7-S-5B	768.5	626.4	615.0	0.0
7-S-5C	767.1	636.9	626.5	3.0
7-S-5D	2092.4	1719.9	1336.0	375.5
7-S-6A	517.4	379.4	363.5	2.6
7-S-6B	725.9	630.0	451.5	163.5
7-S-6C	619.8	542.9	360.6	180.4
7-S-6D	2132.1	1835.0	944.7	812.4
7-S-7A	662.1	479.9	328.5	126.7
7-S-7B	841.7	681.1	494.2	181.6
7-S-7C	569.8	466.5	364.1	95.6
7-S-7D	2712.3	2203.7	1183.8	998.5
7-S-8A	514.2	392.5	313.3	76.8
7-S-8B	615.7	520.7	406.0	113.5
7-S-8C	995.8	845.4	598.5	239.6
7-S-8D	2278.6	1937.9	1326.5	591.3

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S-9A	422.4	346.3	320.0	9.2
7-S-9B	568.9	492.4	454.8	27.4
7-S-9C	812.7	694.1	625.8	32.3
7-S-9D	2177.2	1820.4	1425.0	372.4
7-S-10A	425.8	389.5	310.4	71.0
7-S-10B	473.7	339.6	243.3	89.8
7-S-10C	1027.5	754.1	514.5	198.2
7-S-10D	2065.3	1801.6	1080.0	697.4
7-S-11A	305.5	262.2	239.1	1.7
7-S-11B	636.2	577.4	506.5	59.6
7-S-11C	800.9	729.0	600.0	123.5
7-S-11D	2341.4	2087.6	1171.5	874.9
7-S-12A	638.8	415.4	308.8	101.9
7-S-12B	562.1	439.7	324.8	105.6
7-S-12C	843.7	699.4	511.3	176.1
7-S-12D	1845.4	1630.3	1038.2	538.2
7-S-13A	827.9	522.9	414.8	97.7
7-S-13B	728.5	509.4	322.9	180.2
7-S-13C	480.0	362.6	176.5	180.4
7-S-13D	2262.1	2096.4	867.7	860.0
7-S-14A	397.4	338.6	330.2	5.7
7-S-14B	779.4	721.7	489.5	203.1
7-S-14C	817.2	726.8	290.6	227.7
7-S-14D	2602.8	2172.6	1231.2	927.5
7-S-15A	700.7	607.7	469.0	136.6
7-S-15B	623.6	532.1	340.6	187.6
7-S-15C	826.2	657.6	477.1	175.2
7-S-15D	2618.7	2107.4	1039.4	1052.4
7-S-16A	714.2	617.7	486.0	124.5
7-S-16B	650.0	540.2	476.9	60.8
7-S-16C	889.6	728.6	519.8	191.2
7-S-16D	2128.0	1775.5	939.3	812.0

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S-17A	483.4	456.0	348.6	99.0
7-S-17B	1180.0	1070.0	529.7	523.6
7-S-17C	1184.0	1040.0	575.6	444.4
7-S-17D	2556.8	2150.0	1190.3	943.2
7-S-18A	371.3	339.8	310.0	23.3
7-S-18B	621.7	570.3	494.5	67.1
7-S-18C	756.3	693.5	557.6	132.3
7-S-18D	2013.1	1875.5	901.8	965.4
7-S-19A	385.4	319.3	279.8	38.0
7-S-19B	549.2	483.3	400.4	74.5
7-S-19C	698.3	626.0	449.5	175.0
7-S-19D	2488.9	2190.0	1156.5	1012.7
7-S-20A	417.3	319.5	306.3	9.1
7-S-20B	452.9	375.0	360.4	7.7
7-S-20C	921.8	785.4	647.5	135.1
7-S-20D	2368.4	2220.0	830.8	1380.2
7-S-21A	583.1	397.4	303.6	90.4
7-S-21B	522.7	426.9	169.1	53.8
7-S-21C	775.4	647.1	512.9	131.0
7-S-21D	2128.5	1775.3	935.8	818.0
7-S-22A	357.8	271.0	177.6	89.4
7-S-22B	306.4	270.3	119.3	68.2
7-S-22C	784.3	678.9	537.5	139.2
7-S-22D	2538.0	2168.8	1147.8	1006.3
7-S-23A	297.7	196.6	107.2	84.9
7-S-23B	573.5	481.3	422.0	57.1
7-S-23C	895.3	745.0	562.2	176.7
7-S-23D	3069.5	2603.0	1094.7	1473.3
7-S-24A	501.7	372.0	221.8	147.2
7-S-24B	794.2	646.0	480.4	159.7
7-S-24C	988.7	822.0	556.9	249.5
7-S-24D	2028.6	1701.0	947.5	721.8

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S-25A	356.3	300.0	179.1	113.4
7-S-25B	523.9	470.0	415.8	45.8
7-S-25C	524.1	467.0	406.8	51.3
7-S-25D	2261.9	1992.0	1089.3	826.2
7-S-25E	1695.4	1497.0	834.6	615.3
7-S-33A	408	379	307	67
7-S-33B	604	553	536	8
7-S-33C	737	669	606	56
7-S-33D	2419	2161	1152	1000
7-S-34A	522	449	423	15
7-S-34B	572	485	470	1
7-S-34C	740	637	618	9
7-S-34D	1842	1575	979	587
7-S-35A	718	586	561	13
7-S-35B	798	655	609	35
7-S-35C	801	639	586	40
7-S-35D	2188	1763	1194	555
7-S-36A	677	630	552	72
7-S-36B	600	535	477	52
7-S-36C	978	840	553	278
7-S-36D	2250	1768	803	957
7-S-37A	589	518	509	1
7-S-37B	335	281	258	11
7-S-37C	604	454	280	166
7-S-37D	2371	1910	980	935
7-S-38A	764	677	653	17
7-S-38B	435	373	311	55
7-S-38C	1001	840	658	172
7-S-38D	2029	1681	983	695

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
		SOIL BORINGS		
7-S41-1	452	394	312	74
7-S41-2	359	311	205	27
7-S41-3	314	268	173	15
7-S41-4	551	470	399	66
7-S41-5	680	521	335	178
7-S42-1	426	363	265	88
7-S42-2	416	356	235	113
7-S42-3	422	359	293	58
7-S42-4	432	352	306	39
7-S42-5	583	441	381	45
7-S42-6	564	435	274	157
7-S42-7	915	685	510	171
7-S42-8	744	549	318	225
7-S42-9	197	150	80	44
7-S42-10	583	497	323	170
7-S43-1	439	380	203	164
7-S43-2	352	330	176	72
7-S43-3	342	293	132	74
7-S43-4	346	296	234	50
7-S43-5	494	419	347	68
7-S43-6	695	584	474	106
7-S43-7	566	446	243	198
7-S43-8	692	514	288	219
7-S43-9	779	607	394	207
7-S43-10	576	454	344	107
7-S44-1	395	339	272	64
7-S44-2	540	453	314	130
7-S44-3	693	571	422	138
7-S44-4	614	481	423	52
7-S44-5	510	398	349	40
7-S44-6	769	561	429	122
7-S44-7	473	353	244	103
7-S44-8	490	368	273	85
7-S44-9	842	672	450	217

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S45-1	387	326	281	26
7-S45-2	448	378	324	37
7-S45-3	360	304	269	22
7-S45-4	184	151	103	18
7-S45-5	419	323	212	105
7-S45-6	563	468	268	195
7-S45-7	714	557	416	138
7-S45-8	804	591	438	146
7-S45-9	685	511	425	80
7-S45-10	811	641	470	164
7-S46-1	491	419	352	59
7-S46-2	423	359	292	52
7-S46-3	302	257	133	44
7-S46-4	407	341	284	50
7-S46-5	437	353	230	115
7-S46-6	477	382	231	144
7-S46-7	836	655	498	148
7-S46-8	566	432	305	123
7-S46-9	737	519	498	12
7-S46-10	848	670	407	260
7-S47-1	465	403	309	88
7-S47-2	528	448	379	62
7-S47-3	349	299	201	48
7-S47-4	327	279	198	15
7-S47-5	523	418	245	166
7-S47-6	479	388	195	182
7-S47-7	559	443	321	117
7-S47-8	658	496	461	27
7-S47-9	775	583	395	179
7-S47-10	796	611	420	180
7-S48-1	340	290	256	12
7-S48-2	397	338	289	29
7-S48-3	421	350	238	102
7-S48-4	337	279	250	18
7-S48-5	464	379	259	107
7-S48-6	336	264	225	26
7-S48-7	537	401	323	70
7-S48-8	283	208	189	0
7-S48-9	572	479	324	150
7-S48-10	635	546	322	217

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S49-1	383	332	303	16
7-S49-2	347	295	238	13
7-S49-3	459	393	317	67
7-S49-4	478	382	338	35
7-S49-5	670	508	464	36
7-S49-6	663	512	407	102
7-S49-7	670	500	357	130
7-S49-8	754	555	341	206
7-S49-9	659	456	324	124
7-S49-10	775	597	397	191
7-S50-1	412	354	299	49
7-S50-2	463	392	267	115
7-S50-3	391	329	297	17
7-S50-4	437	361	330	14
7-S50-5	602	462	413	37
7-S50-6	562	468	332	125
7-S50-7	473	360	326	27
7-S50-8	756	577	485	84
7-S50-9	598	460	381	74
7-S50-10	855	700	423	270
7-S51-1	461	392	346	36
7-S51-2	129	109	76	2
7-S51-3	322	305	48	241
7-S51-4	494	440	230	201
7-S51-5	535	464	260	197
7-S51-6	618	495	410	80
7-S51-7	392	328	221	103
7-S51-8	504	401	347	47
7-S51-9	559	423	379	34
7-S51-10	991	770	619	43
7-S52-1	470	403	353	27
7-S52-2	389	333	292	25
7-S52-3	386	330	282	36
7-S52-4	472	396	347	41
7-S52-5	580	449	404	33
7-S52-6	761	591	457	24
7-S52-7	649	496	433	54
7-S52-8	622	476	377	91
7-S52-9	709	547	456	82
7-S52-10	342	296	259	27

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S53-1	306	254	236	8
7-S53-2	421	356	320	27
7-S53-3	483	369	355	3
7-S53-4	661	521	406	109
7-S53-5	687	516	461	45
7-S53-6	470	358	294	58
7-S53-7	923	688	595	89
7-S53-8	455	358	277	78
7-S53-9	654	527	415	107
7-S53-10	1191	938	707	227
7-S54-1	401	339	300	30
7-S54-2	395	334	250	72
7-S54-3	531	451	363	83
7-S54-4	670	515	456	52
7-S54-5	692	531	421	107
7-S54-6	665	518	369	146
7-S54-7	796	617	470	143
7-S54-8	85	69	38	16
7-S54-9	747	608	372	227
7-S54-10	1086	885	453	428
7-S55-1	272	239	185	50
7-S55-2	307	271	181	85
7-S55-3	385	329	235	89
7-S55-4	479	376	240	33
7-S55-5	751	580	450	125
7-S55-6	580	451	308	140
7-S55-7	687	532	402	125
7-S55-8	906	705	471	229
7-S55-9	634	521	311	202
7-S55-10	942	741	442	289
7-S99-1	341	304	255	45
7-S99-2	441	384	330	50
7-S99-3	331	278	221	18
7-S99-4	249	203	140	9
7-S99-5	463	356	281	48
7-S99-6	790	625	521	102
7-S99-7	717	545	334	210
7-S99-8.5	984	708	502	199
7-S99-9.5	558	434	374	55
7-S99-10.5	847	658	555	101

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S100-1		276	239	35
7-S100-2	436	389	335	50
7-S100-3	440	436	330	45
7-S100-4	409	330	273	57
7-S100-5	622	477	350	127
7-S100-6	677	544	396	147
7-S100-8	904	637	391	246
7-S100-9	779	592	320	269
7-S100-10	977	749	544	200
7-S101-1	322	275	249	24
7-S101-2	389	339	285	54
7-S101-3	401	342	288	15
7-S101-4	453	356	258	75
7-S101-5	477	364	244	120
7-S101-6	713	523	417	97
7-S101-7	915	660	391	259
7-S101-8	914	688	474	207
7-S101-9	329	221	138	60
7-S101-10	621	495	438	51
7-S102-1	357	329	301	21
7-S102-2	395	357	302	47
7-S102-3	352	303	229	3
7-S102-4	373	298	201	20
7-S102-5	650	481	378	102
7-S102-6	772	569	424	139
7-S102-7	553	403	317	82
7-S102-8	829	649	402	227
7-S102-9	824	684	507	176
7-S102-10	781	662	436	207
7-S103-1	338	300	210	90
7-S103-2	440	382	260	122
7-S103-3	464	387	200	185
7-S103-4	437	321	240	70
7-S103-5	409	360	197	122
7-S103-6	597	346	260	77
7-S103-7	645	470	213	157
7-S103-8	677	495	342	153
7-S103-9	680	537	383	152
7-S103-10	582	475	343	131

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S104-1	280	245	181	62
7-S104-2	219	190	166	17
7-S104-3	458	385	270	113
7-S104-4	430	332	247	83
7-S104-5	499	384	320	58
7-S104-6	590	473	297	174
7-S104-7	494	300	242	43
7-S104-8	340	282	177	100
7-S104-9	772	594	383	207
7-S104-10	892	686	406	269
7-S105-1	330	286	252	28
7-S105-2	222	200	173	25
7-S105-3	159	140	111	10
7-S105-5	321	300	184	129
7-S105-6	504	475	339	123
7-S105-7	531	492	370	108
7-S105-8	563	512	388	109
7-S105-9	625	622	369	253
7-S105-10	684	680	360	320
7-S106-1	347	305	271	31
7-S106-2	364	319	302	12
7-S106-3	254	214	166	44
7-S106-4	151	120	89	6
7-S106-5	636	464	216	248
7-S106-6	744	559	371	182
7-S106-7	735	538	383	152
7-S106-8	803	572	397	169
7-S106-9	704	487	329	156
7-S106-10	806	615	323	288
7-S107-1	299	261	232	28
7-S107-2	392	348	303	42
7-S107-3	323	271	244	22
7-S107-4	352	270	178	89
7-S107-5	602	450	203	245
7-S107-6	725	539	373	163
7-S107-7	683	499	315	182
7-S107-8	712	521	375	141
7-S107-9	546	451	243	207
7-S107-10	622	482	345	136

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S108-1	391	349	313	33
7-S108-2	299	262	194	66
7-S108-3	440	368	244	122
7-S108-4	338	259	120	113
7-S108-5	580	427	326	100
7-S108-6	771	593	386	204
7-S108-7	328	242	151	89
7-S108-8	669	480	349	128
7-S108-9	517	403	280	120
7-S108-10	606	494	327	165
7-S109-1	336	298	268	27
7-S109-2	377	339	296	41
7-S109-3	381	329	299	30
7-S109-4	411	332	259	70
7-S109-5	287	216	154	16
7-S109-6	679	508	370	132
7-S109-7	457	351	196	147
7-S109-8	729	527	308	211
7-S109-9	709	500	337	157
7-S109-10	568	436	322	112
7-S110-1	331	306	267	26
7-S110-2	261	239	205	20
7-S110-3	338	305	269	20
7-S110-4	404	337	220	104
7-S110-5	472	375	318	47
7-S110-6	697	536	308	219
7-S110-7	741	600	344	244
7-S110-8	742	550	282	256
7-S110-9	171	120	106	1
7-S110-10	313	229	142	87
7-S111-1	294	262	153	101
7-S111-2	59	49	13	32
7-S111-3	310	249	182	66
7-S111-4	220	177	130	36
7-S111-5	394	323	163	149
7-S111-6	478	376	272	100
7-S111-7	459	364	203	160
7-S111-8	697	531	375	156
7-S111-9	570	422	320	99
7-S111-10	574	437	342	95

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S112-1	289	252	177	62
7-S112-3	296	235	155	80
7-S112-4	387	305	238	65
7-S112-5	291	231	133	80
7-S112-6	580	471	260	209
7-S112-7	604	466	315	149
7-S112-8	545	422	295	125
7-S112-9	547	409	330	60
7-S112-10	624	452	380	70
7-S113-1	349	307	273	32
7-S113-2	288	257	165	90
7-S113-3	394	338	209	129
7-S113-4	469	379	246	132
7-S113-5	307	243	116	66
7-S113-6	285	219	125	69
7-S113-7	661	517	322	195
7-S113-8	476	369	245	120
7-S113-9	727	588	258	329
7-S113-10	800	623	340	280
7-S114-1	328	278	218	52
7-S114-2	441	378	238	140
7-S114-3	234	202	68	78
7-S114-4	459	371	223	144
7-S114-5	309	242	91	52
7-S114-6	529	436	245	191
7-S114-7	280	226	128	78
7-S114-8	587	464	320	140
7-S114-9	516	407	320	85
7-S114-10	503	432	172	260
7-S115-1	377	318	287	30
7-S115-2	436	368	244	115
7-S115-3	305	252	201	50
7-S115-4	302	243	182	50
7-S115-5	425	337	195	140
7-S115-6	435	353	220	133
7-S115-7	520	419	210	201
7-S115-8	429	359	145	210
7-S115-9	887	722	357	365
7-S115-10	462	364	300	60

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S116-1	358	298	228	66
7-S116-2	278	240	165	75
7-S116-3	341	285	201	67
7-S117-1	241	202	109	92
7-S117-2	109	92	52	40
7-S117-3	153	126	81	36
7-S118-1	159	136	90	41
7-S118-2	99	88	29	58
7-S119-1	362	294	244	50
7-S119-2	156	128	98	24
7-S120-1	99	76	69	5
7-S120-2	524	494	318	170
7-S120-3	175	160	139	20
7-S121-1	212	185	116	65
7-S121-2	243	217	106	110
7-S121-3	176	151	101	50
7-S122-1	378	322	282	38
7-S122-2	310	267	190	75
7-S122-3	384	321	242	75
7-S122-4	277	223	165	36
7-S122-5	409	327	221	105
7-S122-6	524	444	212	230
7-S122-7	559	436	371	60
7-S122-8	439	370	213	152
7-S122-9	440	362	155	205
7-S122-10	118	99	44	55
7-S123-1	271	237	161	70
7-S123-2	311	255	196	50
7-S123-3	324	254	196	40
7-S123-4	341	272	219	40
7-S123-5	134	102	79	9
7-S123-6	429	352	189	60
7-S123-7	514	434	191	240
7-S123-8	527	442	262	180
7-S123-9	460	378	242	135
7-S123-10	532	448	220	225

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S124-1	90	78	14	58
7-S124-2	86	72	21	50
7-S124-3	214	170	146	16
7-S124-4	444	343	229	109
7-S124-5	571	436	309	123
7-S124-6	498	393	286	106
7-S124-7	698	521	407	105
7-S124-8	447	328	288	40
7-S124-9	583	478	240	233
7-S124-10	306	269	168	98
7-S125-1	333	296	181	114
7-S125-2	391	328	237	92
7-S125-3	353	282	223	46
7-S125-4	327	251	181	65
7-S125-5	482	381	208	173
7-S125-6	544	446	247	198
7-S125-7	575	447	287	159
7-S125-8	643	503	344	159
7-S125-9	473	380	209	171
7-S125-10	515	430	155	275
7-S126-1	311	262	229	30
7-S126-2	211	179	136	38
7-S126-3	368	298	196	86
7-S126-4	369	279	159	94
7-S126-5	461	336	27	312
7-S126-6	384	290	249	44
7-S126-7	428	326	213	114
7-S126-8	494	394	165	216
7-S126-9	511	415	178	236
7-S126-10	470	392	185	210
7-S127-1	533	469	256	216
7-S127-2	362	304	199	83
7-S127-3	406	322	237	48
7-S127-4	167	130	81	39
7-S127-5	558	318	237	151
7-S127-6	735	568	435	133
7-S127-7	538	421	298	128
7-S127-8	548	419	293	131
7-S127-9	661	512	363	153
7-S127-10	924	735	440	299

TABLE 6
(cont'd.)

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight, grams	Dry Weight, grams	Sieved Weight, grams	Rocks and Dross, grams
7-S128-1	424	362	270	95
7-S128-2	311	262	214	47
7-S128-3	451	369	249	119
7-S128-4	507	386	294	94
7-S128-5	409	311	234	79
7-S128-6	448	341	296	49
7-S128-7	446	331	291	44
7-S128-8	467	359	298	64
7-S128-9	515	421	177	247
7-S128-10	497	405	132	275
7-S129-1	347	311	264	33
7-S129-2	298	176	132	27
7-S129-3	170	149	98	22
7-S129-4	495	397	297	89
7-S129-5	411	322	282	32
7-S129-6	427	350	235	105
7-S129-7	471	397	156	230
7-S129-8	431	362	136	215
7-S129-9	462	391	170	212
7-S129-10	486	415	184	225
7-S130-1	357	316	239	73
7-S130-2	367	317	264	49
7-S130-3	313	258	165	37
7-S130-4	525	432	297	127
7-S130-5	524	339	230	213
7-S130-6	522	428	285	140
7-S130-7	500	391	326	62
7-S130-8	396	321	296	21
7-S130-9	460	371	354	15
7-S130-10	286	222	212	7
7-S131-1	289	257	196	59
7-S131-2	359	307	259	41
7-S131-3	324	269	230	26
7-S131-4	381	310	200	108
7-S131-5	464	355	289	63
7-S131-6	466	351	317	34
7-S131-7	582	416	403	11
7-S131-8	515	432	214	216
7-S131-9	433	363	157	201
7-S131-10	484	400	240	158

TABLE 7

ALPHA SPECTRAL RESULTS FOR THROIUM-228 AND THORIUM-232

Sample No.	pCi/g ± σ ^{228}Th	^{232}Th
	BACKGROUND SOIL SAMPLES	
7-SB1-A	0.856 ± 0.107	1.10 ± 0.11
7-SB1-B	0.924 ± 0.062	1.05 ± 0.07
7-SB1-C	0.946 ± 0.072	0.898 ± 0.068
7-SB1-D	0.940 ± 0.081	0.994 ± 0.081
7-SB3-A	0.856 ± 0.062	0.940 ± 0.068
7-SB3-B	1.27 ± 0.080	1.09 ± 0.072
7-SB3-C	1.11 ± 0.072	1.05 ± 0.072
7-SB3-D	1.12 ± 0.088	1.08 ± 0.083
	SOIL SAMPLES	
7-S10-A	635 ±21	645 ±21
7-S10-B	1120 ±80	1200 ±86
7-S10-C	486 ±25	540 ±28
7-S10-D	138 ± 6	158 ± 6
7-S11-A	56.5 ± 2.3	57.3 ± 2.3
7-S11-B	52.5 ± 1.8	60.7 ± 2.0
7-S11-C	21.9 ± 0.8	20.1 ± 0.8
7-S11-D	10.0 ± 0.7	8.37 ± 0.64
7-S12-A	125 ± 7	125 ± 7
7-S12-B	170 ±10	198 ±11
7-S12-C	172 ± 9	194 ±10
7-S12-D	15.8 ± 1.4	18.0 ± 1.5
7-S13-A	1.04 ± 0.142	0.991± 0.129
7-S13-B	0.984 ± 0.074	1.06 ± 0.08
7-S13-C	1.11 ± 0.10	0.996± 0.088
7-S13-D	0.762 ± 0.145	0.850± 0.128
7-S20-A	15.1 ± 0.6	13.9 ± 0.5
7-S20-B	6.42 ± 0.35	5.49 ± 0.31
7-S20-C	217 ±12	205 ±11
7-S20-D	452 ±19	380 ±16
7-S21-A	2.42 ± 0.11	2.45 ± 0.11
7-S21-B	0.808 ± 0.081	0.640± 0.068
7-S21-C	0.583 ± 0.106	0.978± 0.143
7-S21-D	0.353 ± 0.046	0.362± 0.041

TABLE 7
(cont'd.)

ALPHA SPECTRAL RESULTS FOR THORIUM-228 AND THORIUM-232

Sample No.	^{228}Th	^{232}Th
7-S22-A	15.3 ± 0.69	8.10 ± 0.48
7-S22-B	32.6 ± 0.9	21.0 ± 0.7
7-S22-C	5.07 ± 0.37	2.47 ± 0.23
7-S22-D	1.94 ± 0.25	1.44 ± 0.18
7-S23-A	31.4 ± 0.94	8.99 ± 0.42
7-S23-B	4.56 ± 0.27	1.08 ± 0.14
7-S23-C	0.80 ± 0.34	0.42 ± 0.13
7-S23-C	0.72 ± 0.17	0.53 ± 0.11
7-S24-A	1.39 ± 0.09	1.37 ± 0.09
7-S24-B	1.11 ± 0.08	1.07 ± 0.07
7-S24-C	0.975 ± 0.080	0.887± 0.073
7-S24-D	1.14 ± 0.12	1.09 ± 0.09
7-S25-A	1.67 ± 0.08	1.65 ± 0.08
7-S25-B	1.85 ± 0.11	1.90 ± 0.12
7-S25-C	1.13 ± 0.05	1.10 ± 0.05
7-S25-D	1.04 ± 0.05	1.08 ± 0.05
7-S25-E	1.06 ± 0.06	0.983± 0.056
7-S82	260 ±25	230 ±20

	^{228}Th	^{230}Th	^{232}Th
7-S101-1	24.1 ± 0.9	4.6 ± 0.4	22.4 ± 0.9
7-S103-1	28.2 ± 0.6	3.6 ± 0.2	29.0 ± 0.6
7-S109-1	13.9 ± 0.6	2.1 ± 0.3	11.0 ± 0.6
7-S110-1	5.7 ± 0.5	2.1 ± 0.2	4.0 ± 0.3
7-S111-1	21.5 ± 1.3	3.7 ± 0.4	18.5 ± 1.2
7-S113-1	10.0 ± 0.6	1.7 ± 0.3	10.3 ± 0.6
7-S116-1	45.0 ± 2.0	4.5 ± 0.2	43.3 ± 3.0
7-S116-2	4.4 ± 0.2	1.5 ± 0.2	4.3 ± 0.2
7-S116-3	5.9 ± 0.4	1.8 ± 0.2	5.5 ± 0.3
7-S120-1	22.4 ± 1.5	3.8 ± 0.5	22.6 ± 1.5
7-S121-1	18.0 ± 2.0	8.6 ± 0.9	14.0 ± 2.0
7-S121-2	5.1 ± 0.4	2.1 ± 0.2	4.8 ± 0.4
7-S121-3	4.2 ± 0.4	2.5 ± 0.4	4.1 ± 0.4
7-S123-1	98.0 ± 5.0	12.0 ± 2.0	81.0 ± 4.0
7-S128-1	363.0 ±30.0	38.0 ±10.0	368.0 ±30.0

TABLE 7
(cont'd.)

ALPHA SPECTRAL RESULTS FOR THORIUM-238 AND THORIUM-232

pCi/mℓ ± σ

7-W83	9.0 ± 1.0	3.0 ± 0.5
7-W84	0.5 ± 0.2	0.2 ± 0.2
7-W85	1.0 ± 0.3	1.0 ± 0.3
7-W86	1.0 ± 0.3	0.8 ± 0.3
7-W87	2.0 ± 0.3	1.0 ±0.3
7-W88	19.0 ± 1.0	17.0 ± 1.0

pCi/g ± σ

Sample No.	^{228}Th	^{230}Th	^{232}Th
7-SS-41	$\leq 5 \times 10^{-4}$	$\leq 3 \times 10^{-4}$	$\leq 3 \times 10^{-4}$
7-SS-42	$\leq 8 \times 10^{-4}$	$< 4 \times 10^{-4}$	$\leq 2 \times 10^{-4}$
7-SS-43	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$	$\leq 3 \times 10^{-4}$
7-SS-44	$\leq 5 \times 10^{-3}$	$\leq 2 \times 10^{-3}$	$\leq 2 \times 10^{-4}$
7-SS-45	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$
7-SS-46	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$
7-SS-47	$\leq 2 \times 10^{-4}$	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-3}$
7-SS-48	$\leq 1 \times 10^{-4}$	$\leq 2 \times 10^{-3}$	$\leq 6 \times 10^{-3}$
7-SS-49	$\leq 3 \times 10^{-4}$	$\leq 5 \times 10^{-4}$	$\leq 3 \times 10^{-4}$
7-SS-50	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$
7-SS-51	5.9 ± 0.7	10 ± 1	2.5 ± 0.2
7-SS-52	2.4 ± 0.2	3.5 ± 0.2	1.8 ± 0.2
7-SS-53	18 ± 1	17 ± 1	16.4 ± 1.6
7-SS-54	0.5 ± 0.2	1.2 ± 0.4	0.5 ± 0.2
7-SS-55	2.9 ± 0.2	2.3 ± 0.3	3.4 ± 0.3
7-SS-56	29 ± 4	19 ± 5	5 ± 2
7-SS-57	0.6 ± 0.1	0.5 ± 0.1	0.7 ± 0.2
7-SS-58	1.1 ± 0.2	1.0 ± 0.2	1.0 ± 0.2
7-SS-59	1.4 ± 0.2	1.2 ± 0.2	0.8 ± 0.1
7-SS-60	$\leq 4 \times 10^{-4}$	$\leq 4 \times 10^{-4}$	$\leq 4 \times 10^{-4}$

TABLE 7
(cont'd.)

ALPHA SPECTRAL RESULTS FOR THORIUM-228 AND THORIUM-232

pCi/g ± σ

7-SS-61	$\leq 4 \times 10^{-4}$	$\leq 4 \times 10^{-4}$	$\leq 4 \times 10^{-4}$
7-SS-62	0.7 ± 0.3	1.0 ± 0.3	0.9 ± 0.3
7-SS-63	$\leq 4 \times 10^{-4}$	$\leq 6 \times 10^{-4}$	$\leq 4 \times 10^{-4}$
7-SS-64	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$	$\leq 5 \times 10^{-4}$
7-SS-65	≤ 0.1	0.5 ± 0.3	≤ 0.1
7-SS-66	≤ 0.2	0.5 ± 0.1	≤ 0.1
7-SS-67	≤ 1	16 ± 1	≤ 1

TABLE 8

Ge(Li) SPECTRAL AND URANIUM FLUOROMETRIC ANALYSES
OF WATER AND SLUDGE SAMPLES

Sample No.	Ge(Li) Spectra pCi/g±σ ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium Fluorometric	
7S82	1.45±0.10	215 ±15	2.62±0.18	15.1 mg/g	10.4 nCi/g
7W83	0.06±0.03	< 0.06	0.05±0.03	22 ng/mℓ	0.015 pCi/mℓ
7W84	0.03±0.02	< 0.06	<0.02	2.9 ng/mℓ	0.002 pCi/mℓ
7W85	<0.03	< 0.06	<0.02	< 1 ng/mℓ	<0.0007 pCi/mℓ
7W86	<0.03	< 0.06	<0.02	< 1 ng/mℓ	<0.0007 pCi/mℓ
7W87	<0.03	0.06±0.03	<0.02	3.4 ng/mℓ	0.002 pCi/mℓ
7-SS-41				2.0 ng/mℓ	0.0014 pCi/mℓ
7-SS-42				1.4 ng/mℓ	0.0010 pCi/mℓ
7-SS-43				1.7 ng/mℓ	0.0012 pCi/mℓ
7-SS-44				3.8 ng/mℓ	0.0027 pCi/mℓ
7-SS-45				1.4 ng/mℓ	0.0010 pCi/mℓ
7-SS-46				1.9 ng/mℓ	0.0013 pCi/mℓ
7-SS-47				1.6 ng/mℓ	0.0011 pCi/mℓ
7-SS-48				5.9 ng/mℓ	0.0041 pCi/mℓ
7-SS-49				5.2 ng/mℓ	0.0036 pCi/mℓ
7-SS-50				1.9 ng/mℓ	0.0013 pCi/mℓ
7-SS-51*				28.7 µg/g	20.1 pCi/g
7-SS-52*				23.2 µg/g	16.2 pCi/g
7-SS-53				83.0 µg/g	58.0 pCi/g
7-SS-54				0.6 µg/g	0.4 pCi/g
7-SS-55	<0.03	BDL[b]	0.04±0.16	25.5 µg/g	17.8 pCi/g
7-SS-56				118.0 µg/g	82.5 pCi/g
7-SS-57	0.04±0.02	0.94±0.09	0.76±0.08	4.7 µg/g	3.3 pCi/g
7-SS-58				19.9 µg/g	6.9 pCi/g
7-SS-59	0.08±0.03	2.16±0.22	0.72±0.07	5.1µg/g	3.6 pCi/g
7-SS-60				1.2 ng/mℓ	0.0008 pCi/mℓ
7-SS-61				1.3 ng/mℓ	0.0009 pCi/mℓ
7-SS-62				2.2 µg/g	1.5 pCi/g
7-SS-63				1.0 ng/mℓ	0.0007 pCi/mℓ
7-SS-64				1.2 ng/mℓ	0.0008 pCi/mℓ
7-SS-65				3.3 µg/g	2.3 pCi/g
7-SS-66				3.6 µg/g	2.5 pCi/g
7-SS-67	BDL[b]	0.16±0.64	<0.02	143.0µg/g	100.0 pCi/g

[a]Only a few of the sludge samples were analyzed by gamma spectroscopy since the sample were small and hence sensitivities poor.

[b]BDL = Below Detectable Limit

*Sample 51 was taken before a flush by the sewer department and Sample 52 was tak immediately after the flush.

Table 9

ESTIMATED VOLUME, MASS AND ACTIVITY OF MATERIAL
THAT COULD BE GENERATED BY REMEDIAL ACTION[a]

Area and Material Involved	Estimated Volume		Estimated Mass		Estimated Activity (Curies)[b]	
	m^3	ft^3	kg	lbs. (avoir)	Natural Thorium	Normal Uranium
Bldg. Interiors[(c)] (ρ = 2)	0.13	4.6	2.6×10^2	5.7×10^2	NA[d]	NA[d]
Exterior (ρ = 1.5)	26.2	925	3.9×10^4	8.6×10^4	0.026	0.0014

[a] See text for assumptions upon which estimates are based.

[b] A Curie is 3.7×10^{10} disintegrations per second.

[c] Assumed 1 cm thickness removed (13 m^2 surface area).

[d] Not Applicable (NA) since the material was not analyzed for specific activity (pCi/g).

APPENDIX 1

INSTRUMENTATION

I. PORTABLE RADIATION SURVEY METERS

A. Gas-Flow Proportional Survey Meters

The Eberline PAC-4G-3 was the primary instrument used for surveying. This instrument is a gas-flow proportional counter which utilizes a gas-proportional detector, 51 cm^2 (PAC-4G-3) or 325 cm^2 (FM-4G) in area, with a thin double-aluminized Mylar window (~ 0.85 mg/cm^2).

Since this instrument has multiple high-voltage positions, it can be used to distinguish between alpha and beta-gamma contamination. This instrument was initially used in the beta mode. In the beta mode, the detector responds to alpha and beta paticles and x- and gamma-rays. When areas indicated a higher count rate than the average instrument background, the beta-mode reading was recorded, and the instrument was then switched to the alpha mode to determine any alpha contribution. In the alpha mode, the instrument responds only to particles with high specific ionization. This instrument is calibrated in the alpha mode with a flat-plate infinitely-thin NBS traceable ^{239}Pu standard, and in the beta mode with a flat-plate infinitely-thin NBS traceable ^{90}Sr-^{90}Y standard. The PAC-4G-3 instruments are calibrated to an apparent 50% detection efficiency.

B. Beta-Gamma End Window Survey Meter

When an area of contamination is found with a PAC instrument, a reading is taken with an Eberline Beta-gamma Geiger-Mueller Counter, Model E-530 with a HP-190 probe. This probe has a thin mica end window and is, therefore, sensitive to alpha and beta particles and x- and gamma-rays. A thin piece of aluminum is added to the mica, making the window density approximately 7 mg/cm^2. At this density, the instrument is not sensitive to the majority of alpha emissions. A maximum reading is obtained with the probe placed in contact with the area of contamination. Another reading is obtained with the probe also held 1 m from the contaminated area, and a reading is obtained. This instrument is calibrated with an NBS traceable ^{137}Cs source.

C. Low Energy Gamma Scintillation Survey Meter

An Eberline Model PRM-5-3 with a PG-2 gamma scintillation detector is used to determine low energy x and gamma radiation. The PG-2 detector consists of a thin NaI(Tℓ) scintillation crystal 5 cm in diameter by 2 mm thick. This instrument is calibrated on three separate discriminators for three energy regions using ^{239}Pu (17 keV), ^{241}Am (59.5 keV) and ^{235}U (185.7 keV) sources. This instrument can be operated in either a differential (to discriminate between different energy regions) or integral mode.

APPENDIX 1
(cont'd.)

D. High Energy Micro "R" Scintillation Survey Meter

An Eberline Micro "R" meter model PRM-7 is used to detect high energy gamma radiation. This instrument contains an internally mounted NaI(Tℓ) scintillation crystal 2.5 cm in diameter by 2.5 cm thick and can be used for measuring fields of low-level radiation between 10 μR/h and 5000 μR/h. This instrument is also calibrated with an NBS traceable ^{226}Ra source.

E. Integrating Radiation Meter

In addition to the PRM-7, a pressurized ion chamber (Reuter Stokes Model RSS-111) is used at selected locations to determine the ambient radiation field. The RSS-111 has three output modes; 1) instantaneous exposure rate, 2) strip chart differential readout, and 3) integrated exposure. This instrument is mounted on a tripod, three feet (~ 1 meter) above the surface and has a uniform energy response from about 0.2 MeV to about 4 MeV. A three hour period of operation is usually sufficient to obtain significant data.

II. SMEAR COUNTING INSTRUMENTATION

An ANL designed gas-flow proportional detector connected to an Eberline Mini Scaler Model MS-2 is used to count multiple smears simultaneously. This detector has a double-aluminized Mylar window (400 cm^2) and uses P-10 (90% argon and 10% methane) as the counting gas. The metal sample holder for this detector has been machined to hold ten smear papers. This particular system consists of two Mini Scalers and two detectors. One is used for counting in the alpha mode; the other is used in the beta mode. Up to ten samples can be counted simultaneously.

Any smear taken from a contaminated area is counted individually in a Nuclear Measurements Corporation PC-5 gas-flow proportional counter. This instrument has been modified to contain a double-aluminized Mylar spun top. This top is placed over non-conducting media (e.g. paper smears) to negate the dielectric effect on the counter. This counter also uses P-10 counting gas. Smears are counted in both the alpha and beta modes. This instrument is calibrated by determining the input sensitivity using an alpha source.

III. AIR SAMPLING DEVICE

Air samples are collected using a commercially available (ANL-modified filter queen) vacuum cleaner identified as a "Princess Model." The air was drawn through a filter media at a flow rate of 40 m^3/h. The filter media consist of 200 cm^2 sheets of Hollingsworth-Vose (HV-70 or LB5211-9 mil) filter paper. The collection efficiency at these flow rates for 0.3-micron particles is about 99.9%.

A separate air sample can be taken with a positive displacement pump drawing about 20 liters/min through a millipore (0.5 to 0.8 micron) filter paper

APPENDIX 1
(cont'd.)

for about one hour. An alpha spectrum can be measured from a section of this filter paper. The ratio of actinon (^{219}Rn - 6.62 MeV α AcC) to radon (^{222}Rn - 7.69 MeV RaC') can be determined from this spectrum.

IV. GAMMA SPECTRAL INSTRUMENTATION

A Nuclear Data Multichannel Analyzer Model ND-100, utilizing a 7.6 cm diameter by 7.6 cm thick NaI(Tℓ) scintillation crystal is commonly used for determining gamma spectrum. This instrument is calibrated with NBS traceable gamma sources. Samples from contaminated areas are analyzed using this sytem and the contamination radionuclides are identified.

Hyperpure Germanium detectors (ORTEC - 17% efficiency right-circular cylinders) are used when more sophisticated gamma-ray analyses are required. These detectors are coupled to Nuclear Data Multichannel Analyzers (Models ND-60, ND-66 or ND-100).

APPENDIX 2

CONVERSION FACTORS

I. INSTRUMENTATION

The conversion factors used to obtain the readings in units of disintegrations per minute per 100 cm^2 (dis/min-100 cm^2) and the derivation of those factors are listed below.

A. Conversion Factors

	PAC-4G-3		Floor Monitor (FM-4G)	
	Alpha	Beta	Alpha	Beta
To 100 cm^2	1.96	1.96	0.31	0.31
cts/min to dis/min ^{90}Sr-^{90}Y	-	2	-	2
cts/min to dis/min for ^{239}Pu	2	-	2	-
cts/min to dis/min for normal U	5.9	3.5	5.9	3.5
cts/min to dis/min ^{226}Ra plus daughters	1.6	4.7	-	-

B. Derivation of Conversion Factors

. Floor Monitor

Window Area: ~ 325 cm^2
Conversion to 100 cm^2 = 0.31 times Floor Monitor readings

. PAC-4G-3

Window Area: ~ 51 cm^2
Conversion to 100 cm^2 = 1.96 times PAC reading

. 2π Internal Gas-Flow Counter, PC Counter

Geometry: Solid Steel Spun Top - 0.50

Geometry: Mylar Spun Top - 0.43
Mylar spun top counting {double-aluminized Mylar window (~ 0.85 mg/cm^2)} utilizes the well of the PC counter and is a method developed and used by the Argonne National Laboratory Health Physics Section for negating the dielectric effect in counting samples on nonconducting media.

APPENDIX 2
(Cont'd.)

Using a flat-plate, infinitely thin ^{226}Ra plus short-lived daughters standard as a source of alpha emissions, the plate was counted in the well of a 2π Internal Gas-Flow Counter (PC counter) with the source leveled to an apparent 2π geometry. This instrument was calibrated using ^{239}Pu NBS traceable alpha sources. The alpha counts per minute (cts/min) reading was found to be 1.8×10^4 cts/min, or $1.8 \times 10^4 \div 0.51^* = 3.5 \times 10^4$ disintegrations per minute (dis/min) alpha. Since the source was infinitely-thin, the alpha component was used as the total alpha dis/min of the source.

The same ^{226}Ra plus daughters source, when counted with the PAC instrument in the alpha mode, was found to be 2.2×10^4 cts/min at contact. The conversion factor for cts/min to dis/min for the PAC instrument is $3.5 \times 10^4 \div 2.2 \times 10^4 = 1.6$ dis/min alpha to cts/min alpha.

The same source was covered with two layers of conducting paper, each 6.65 mg/cm^2, to absorb the alpha emissions. With the PAC-4G-3 in the beta mode and in contact with the covered source in the center of the probe, the count was found to be 7.5×10^3 cts/min. This indicates a conversion factor of $3.5 \times 10^4 \div 7.5 \times 10^3 = 4.7$ dis/min alpha to cts/min beta-gamma.

A similar method was used to determine the conversion factors for normal uranium.

II. SMEAR COUNT

The conversion factors for cts/min-100 cm^2 to dis/min-100 cm^2 are given below:

A. Conversion Equation (Alpha)

$$\frac{\text{cts/min - (Bkgd)}}{\text{g x bf x sa x waf}} = \text{dis/min } \alpha$$

A geometry (g) of 0.43 is standard for all flat-plate counting using the Mylar spun top.

A backscatter factor (bf) of 1.0 is used when determining alpha activity on a filter media.

The self-absorption factor (sa) was assumed to be 1, unless otherwise determined.

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*The value of 0.51 includes the following factors: geometry (g) = 0.50; backscatter factor (bf) = 1.02; sample absorption factor (sa) = 1.0; window air factor (waf) = 1.0. The product of g x bf x sa x waf is 0.51.

APPENDIX 2
(Cont'd.)

If the energies of the isotope are known, the appropriate window air factor (waf) is used; if the energies of the isotopes are unknown, the (waf) of ^{239}Pu (0.713) is used.

The (waf) for alpha from ^{226}Ra plus daughters is 0.55.

B. Conversion Equation (Beta)

$$\frac{\text{cts/min} - \{\beta \text{ Bkgd (cts/min)} + \alpha \text{ cts/min}\}}{\text{g x bf x sa x waf}} = \text{dis/min } \beta$$

A geometry (g) of 0.43 is standard for all flat-plate counting using the Mylar spun top.

A backscatter factor (bf) of 1.1 is used when determining beta activity on a filter media.

A self-absorption factor (sa) was assumed to be 1, unless otherwise determined.

If the energies of the isotopes were known, the appropriate window air factor (waf) was used; if the energies of the isotopes were unknown, the (waf) of ^{90}Sr-^{90}Y (0.85) is used.

The (waf) for betas from ^{226}Ra plus daughters is 0.85.

APPENDIX 3

RADON-DETERMINATION CALCULATIONS

Calculations for air samples collected with an Argonne National Laboratory-designed air sampler using HV-70 or LB5211 filter media are summarized in this appendix. The appendix also includes the basic assumptions and calculations used to derive the air concentrations.

I. RADON CONCENTRATIONS

The following postulates are assumed in deriving the radon (^{222}Rn) concentrations as based on the RaC' alpha count results.

A. RaA, RaB, RaC, and RaC' are in equilibrium.

B. RaA is present only in the first count and not the 100-minute decay count.

C. One-half of the radon progeny is not adhered to airborne particulates (i.e., unattached fraction) and, therefore, is not collected on the filter media.

D. The geometry factor (g) is 0.43 for both the alpha and beta activity.

E. The backscatter factor (bf) of 1.0 is used for the alpha activity.

F. The sample absorption factor (sa) for RaC' is 0.77.

G. The window air factor (waf) for RaC' is 0.8.

H. RaB and RaC, being beta emitters, are not counted in the alpha mode.

I. The half-life of the radon progeny is approximately 36 minutes, based on the combined RaB and RaC half-lives.

J. Thoron and long-lived alpha emitters are accounted for using the 360 count and the seven-day count, respectively.

K. For all practical purposes, RaC' decays at the rate of the composite of RaB and RaC, which is about 36 minutes.

The following postulates are assumed in deriving the thoron (^{220}Rn) concentrations.

L. ThA, ThB, ThC and ThC' are in equilibrium.

M. ThA and RaC' have have decayed by the 360-minute decay count.

APPENDIX 3
(cont'd.)

N. The geometry factor (g), backscatter factor (bf), sample absorption factor (sa) and window air factor (waf) are all the same for thoron as for radon.

O. ThB and 64% of ThC, being beta emitters, are not counted in the alpha mode.

P. The half-life of the thoron progeny is 10.64 hours (638.4 min) based on the ThB half-life.

Q. For all practical purposes 36% of the ThC (alpha branch) and the ThC' decay at the decay rate of ThB which is 638.4 min.

R. The counter does not differentiate between the ThC alphas and the ThC' alphas.

The following postulates are assumed in deriving the actinon (^{219}Rn) concentrations.

S. AcA, AcB and AcC are in equilibrium.

T. AcA has decayed by the 100 minute decay count.

U. The geometry (g), backscatter (bf), sample absorption (sa) and window air factor (waf) factors are all the same for actinon as for radon.

V. AcB being a beta emitter is not counted in the alpha mode.

W. The half-life of the actinon progeny is 36.1 minutes based on the AcB half-life.

X. For all practical purposes, the AcC decays at the decay rate of AcB which is 36.1 minutes.

Y. 84% of the AcC decays by 6.62 MeV α emissions and 16% decays by 6.28 MeV α emissions.

The following postulated is assumed in deriving the long-lived concentration. The long-lived activity, as determined from the seven-day count, is assumed to be constant during the entire counting periods. This assumption is valid for isotopes with half-lives longer than a few years.

II. EQUATIONS USED TO DERIVE AIR CONCENTRATIONS

$$A_o = \frac{A}{e^{-\lambda t}}$$

Where: A_o = Activity (dis/min) present at the end of the sampling period (usually 40 minutes)

APPENDIX 3
(cont'd.)

A = Activity (dis/min) at some time, t, after end of the sampling period

t = Time interval (min) from end of sampling period to counting interval (usually $\simeq$ 100 minutes)

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

$t_{\frac{1}{2}}$ = Half-life of isotope (min)

Concentration is determined by the equation:

$$C = \frac{A_o \lambda}{f} \times \frac{1}{1-e^{-\lambda t_s}}$$

Where: C = Concentration (dis/min-m^3)

A_o = Activity on filter media at end of sampling period (dis/min)

f = Sampling rate (m^3/min = m^3/h x 1h/60 minutes)

t_s = Length of sampling time (minute)

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

$t_{\frac{1}{2}}$ = Half-life of isotope or controlling parent (min)

III. ACTINON CORRECTION

Since the actinon (^{219}Rn) progeny (AcA, AcB & AcC) decays at the AcB half-life of 36 min. it cannot be distinguished from the radon (^{222}Rn) progeny using standard air sampling with HV-70 or LB5211 filter media and standard alpha counting techniques. A positive displacement pump is used to collect a sample on millipore (0.5 to 0.8 micron) filter media. The sample rate is approximately 20 liters/min for a sampling time of at least ninety minutes. The center portion of the sample is removed and counted in an alpha spectrometer which exhibits the 6.62 MeV AcC alpha emissions and the 7.69 MeV RaC' alpha emissions. If these two peaks are observed in the spectrum, then the following calculations are performed.

APPENDIX 3
(cont'd.)

$$B_j = \sum_{i=1}^{n} b_{ij}$$

Where: b_i = the number of counts in channel i of peak j.

B_j = Summation of n channels under peak j.

j = 1 for the 6.62 MeV peak of actinon.

j = 2 for the 7.69 MeV peak of radon.

n = total number of channels in the summation.

The fraction of the activity with a 36-minute half-life due to actinon and radon are then:

$$\text{Actinon} = \frac{B_1/.84}{B_1/.84+B_2}$$

$$\text{Radon} = \frac{B_2}{B_1/.84+B_2}$$

Where 1 refers to actinon progeny and 2 refers to radon progeny.

IV. EXAMPLE CALCULATION

Data has been created to correspond to values likely to occur if all possible types of contamination are present in the air of a room where the sample is taken. The application of the equations for determining all types of activity and their concentrations are given below.

Data $\dot{f} = 40\ m^3/60$ min. $t_s = 40$ min.
at $t = 100$ min. $A^s = 2000$ dis/min.
at $t = 360$ min. $A = 140$ dis/min.
at $t = 7$ days $A = 5$ dis/min.

For long-lived activity:

$$A_o = A = 5 \text{ dis/min}$$

$$C(L) = A_o/fxt_s = \frac{5}{40/60 \times 40} = 0.19 \text{ dis/min-m}^3$$

APPENDIX 3
(cont'd.)

For thoron:

$$A_o = \frac{140-5}{\exp - \frac{0.693 \times 360}{638.4}} = 199.6 \text{ dis/min}$$

$$C(Tn) = \frac{199.6 \times \frac{0.693}{638.4}}{40/60} \times \frac{1}{1 - \exp - \frac{0.693 \times 40}{638.4}} = 7.6 \text{ dis/min-m}^3$$

For radon (^{222}Rn) and actinon (^{219}Rn); activity due to thoron at t = 100 min.

$$A = \frac{135}{\exp - \frac{0.693 \times 260}{638.4}} = 179 \text{ dis/min}$$

Activity due to the isotopes with a 36 minute half-life:

$$A = 2000 - 179 - 5 = 1816 \text{ dis/min}$$

$$A_{o=} \frac{1816}{\exp - \frac{0.693 \times 100}{36}} = 12{,}454 \text{ dis/min}$$

$$C(36) = \frac{12{,}454 \times \frac{0.693}{36}}{40/60} \times \frac{1}{1 - \exp \frac{-0.693 \times 40}{36}} = 669.7 \text{ dis/min-m}^3$$

When an actinon peak is seen at 6.62 MeV, then the counts under the two peaks are summed. For example, if 10 channels are summed, the following counts are found.

For 6.62 MeV peak: Forty-four counts in 10 channels, where the 6.62 alpha emissions are 84% of the total.

For 7.69 MeV peak: 601 counts in 10 channels, where the 7.69 MeV alpha emissions are 100% of the total.

APPENDIX 3
(cont'd.)

$B_1 = 44$

$B_1/.84 = 52$ counts

$B_2 = 601$ counts

Actinon = 52/653 = 0.08

Radon = 601/653 = 0.92

C(Rn) = C(36) x Radon% = 669.7 x 0.92 = 616.1 dis/min-m^3

C = C(36) x Actinon% = 669.7 x 0.08 = 53.6 dis/min-m^3

Since we assume that on the average half of the progeny is not adhered to the airborne particulates, the above concentrations are then multiplied by a factor of (2) to determine actual concentrations. We assume that there is no unattached fraction for the long-lived activity.

C actual = C measured x progeny correction factor

C(L) = 0.19 dis/min-m^3

C(Tn) = 7.6 dis/min-m^3 x 2 = 15.2 dis/min-m^3

C(An) = 53.6 dis/min-m^3 x 2 = 107.2 dis/min-m^3

C(Rn) = 616 dis/min-m^3 x 2 = 1232 dis/min-m^3

These would then be the resultant concentrations in dis/min-m^3. To convert to pCi/ℓ, divide the concentrations by 2.2 x 10^3.

$$C(L) = \frac{0.19 \text{ dis/min-m}^3}{2{,}220 \text{ dis/min-m}^3/\text{pCi}/\ell} = 8.6 \times 10^5 \text{ pCi}/\ell$$

$$C(Tn) = \frac{15.2 \text{ dis/min-m}^3}{2{,}220 \text{ dis/min-m}^3/\text{pCi}/\ell} = 0.0068 \text{ pCi}/\ell$$

$$C(An) = \frac{107.2 \text{ dis/min-m}^3}{2{,}220 \text{ dis/min-m}^3/\text{pCi}/\ell} = 0.048 \text{ pCi}/\ell$$

$$C(Rn) = \frac{1232 \text{ dis/min-m}^3}{2{,}220 \text{ dis/min-m}^3/\text{pCi}/\ell} = 0.55 \text{ pCi}/\ell$$

APPENDIX 4

SAMPLE PREPARATION AND ANALYSES GENERIC PROTOCOL

I. SOIL SAMPLE PREPARATION

Soil samples are acquired as previously described. These samples are bagged and identified at the collection site and returned to ANL. If there is an indication of radioactive contamination, the sample is sealed in a nalgene jar. At ANL, the soil samples are logged into the soil sample book and weighed. Each soil sample is weighed (on a tared balance scale) and the weight is marked on the container. This weight is recorded in the soil book as a "net weight."

After all samples are marked, weighed and recorded, they are dried. Each sample is placed in a pyrex beaker marked with the sample identification number. If more than one beaker is necessary, additional numbers (e.g. 1-3, 2-3, 3-3) are used. The original containers are saved for repackaging the dried samples. The beaker is set in an 80°C oven until the soil is dry (approximatley 48 hours). Visual inspection of the soil is sufficient to determine when the soil is dry. The sample is returned to the original container and reweighed using a tared balance scale. This weight is also marked on the container and in the soil sample book where it is referred to as a "dry weight."

After all the samples are returned to their original containers, the milling process is started. Each dried sample is transferred to a 2.3 gallon ceramic mill jar containing mill balls (1¼" x 1¼" Burundum cylinders). The mill jar number is marked on the original container. The jars are sealed and the samples are milled for two hours or until sufficient material is produced to obtain 100 g and 5 g samples for analyses. The samples are milled six at a time. A second set of six jars are prepared while the milling of the first set is proceeding. After each sample is milled, the mill balls are removed with tongs and placed in a tray. A large plastic bag is inverted over the mill jar. Both are inverted and shaken until all the soil is transferred to the bag. If the soil plates the inside of the mill jar, a small paint brush is used to loosen the soil before the jar is inverted. A separate brush is used for each jar to prevent cross-contamination of the soil samples.

After milling, each sample is sieved through a number 30 standard testing sieve (600 μ mesh) and transferred to a 12" x 12" ziplock bag. Rocks and dross are bagged separately. The bags are marked with the sample number, the sieve number and R(rocks) or S(soil). The balance is tared and the weights of the soil (or rocks) are measured and recorded in the Soil Sample Book. A 100 g sample of the sieved material is transferred to a 4 oz. Nalgene bottle. These samples are analyzed by suitable analytical techniques including, as a minimum, gamma spectroscopy (GeLi) as well as radiochemical analyses for plutonium, americium and thorium. A five gram sample of the sieved material is transferred to a 1-oz Nalgene bottle.

APPENDIX 4
(cont'd.)

This sample is used for the determination of uranium by laser fluorometry. The bottles containing these weighed samples are marked with sample number and date and this information is recorded in the Soil Sample Book. The rocks (and dross) and remaining soil are placed in storage.

The sieves, mill jars and Burundum milling balls used in this work are classified in two sets. One set is used for background samples exclusively. The other set is used for all samples from suspect areas. Soil samples, with elevated levels of radioactivity based on instrument measurements, are milled in one gallon Nalgene bottles using Burundum balls from the set used for suspect samples. After use, these balls are either decontaminated (see below) or disposed of as radioactive waste. These Nalgene bottles are always disposed of as radioactive waste. The sieves used for these samples are also from the set used for suspect samples and are decontaminated after using.

II. EQUIPMENT DECONTAMINATION

The care of the milling apparatus is as important as the actual sample preparation. Proper care prevents cross-contamination of successive samples. The beakers used to dry the samples are washed thoroughly by placing a small amount of Haemo-Sol in each beaker and filling with warm water. The beaker is then scrubbed thoroughly on the inside and scoured on the outside with scouring powder. The beakers are then rinsed with tap water (three times) followed by demineralized water (three times) and finally dried thoroughly before reuse.

The milling apparatus (tongs, brushes, milling jars, lids and milling balls) are rinsed. The tongs and brushes are washed thoroughly with Haemo-Sol. Eight Burundum balls are returned to each milling jar along with about one pint of clean road gravel, one spoon of Haemo-Sol, one spoon of scouring powder with bleach, and one quart of water. The lid is tightened on the jar and the jar is placed on the rolling mill and rolled for approximately two hours or until the balls and the inside of the jar appear to be physically clean. After this time, the mill jar is removed from the rolling mill and its contents are dumped into a screen or basket. The lid and balls are then rinsed thoroughly three times with tap water followed by three times with demineralized water. The inside of the jar is rinsed until it is absolutely clean. The milling apparatus is air dried using warm air until absolutely dry. Air is blown through a hose from the oven to the inside of the ceramic jar to dry the jar.

The sieves are rinsed, washed in Haemo-Sol, thoroughly rinsed (three times with tap water, followed by three rinses with demineralized water) and then air dried as above before reuse.

III. WATER AND SLUDGE

Water samples are collected in 0.1 liter, 0.5 liter and/or 1 liter quantities as deemed appropriate. These samples are forwarded directly to a certified radiochemistry laboratory for preparation and analysis. The customary analysis procedure consists of filtration to obtain the suspended solids followed by

APPENDIX 4
(cont'd.)

evaporation to obrain the dissolved solids. Both suspended and dissolved solids are analyzed by appropriate radiochemical analytical techniques.

Sludge samples are collected in 0.1 liter bottles and are processed as delineated above for water samples.

IV. VEGETATION, TRASH AND RUBBLE

Samples of potentially contaminated vegetation, trash (e.g. piping, ducts, conduit, etc.) and rubble are collected, bagged and labeled at the site and returned to ANL for analysis.

Vegetation samples are initially weighed and transferred to Marinelli beakers for gamma spectrometric analysis. Then they are ashed, reweighed and analyzed by appropriate analytical techniques.

Trash and rubble samples are forwarded to a certified radiochemistry laboratory for analysis.

V. TRITIUM FROM SOLID MATERIALS

Samples of solid materials (e.g. concrete) suspected of containing tritium are collected, broken into small pieces and submitted to a certified radiochemistry laboratory for analysis. The standard analytical procedure consists of transferring a 20-40 g sample to a ceramic boat followed by heating in a tube furnace at 425°C for a period of two hours (~ 40 min to reach temperature and ~ 80 min heating at temperature). Helium is used as a flow gas through the tube during heating, and the tritium is colelcted in two traps on the downstream side of the furance. The first trap is immersed in an ordinary ice bath (0°C); the second trap is immersed in a CO_2-Freon bath (-57°C). The collected tritiated water from both traps is combined, made up to a known volume, and an aliquot taken for liquid scintillation counting of the tritium.

VI. ANALYSIS PROCEDURES

A 100 gram fraction from each soil sample is analyzed by high resolution gamma-ray spectroscopy using a germanium crystal detector coupled to a multichannel analyzer. This analysis allows for a quantitative determination of the ^{226}Ra decay chain (via the 609 keV γ-ray of ^{214}Bi) and the ^{232}Th decay chain (via the 908 keV γ-ray of ^{228}Ac as well as any other gamma emitting radionuclide (e.g. ^{137}Cs) present in the soil.

The total uranium (elemental) present in the soil is determined by an acid leach of the soil sample followed by laser fluorometry of the leached sample.

Thorium analysis consists of an acid leach of the soil (using a ^{234}Th spike for yield determination) followed by plating a thin source of the radiochemically separated thorium and determining the thorium isotopes (^{228}Th and ^{232}Th) by alpha spectroscopy.

APPENDIX 4
(cont'd.)

The results of the above measurements allow for quantitative determination of the relative amounts of normal uranium, natural uranium, tailings (i.e., ^{226}Ra decay chain), thorium (^{232}Th), mesothorium (^{228}Ra decay chain) and thorium (^{228}Th) decay chain present in the contaminated material.

A mass spectrometric analysis of the uranium fraction is conducted when it is known or is is surmised that depleted or enriched uranium might be present.

APPENDIX 5

CALCULATION OF NORMAL-URANIUM SPECIFIC ACTIVITY

The specific activity for normal uranium was obtained by summing the measured specific activities for the individual isotopes weighted according to their normal abundances. Best values for these specific activities were taken from A. H. Jaffey, et al. Phys. Rev. 4 1889 (1971). The percent abundance and half-life for each isotope were taken from the "Table of Isotopes," 7th Edition by C. M. Lederer and V. S. Shirley (1978). Atomic weights were taken from the Handbook of Chemistry and Physics, 52nd Edition (1971).

Isotope	Specific Activity	Half-life (years)	Abundance (atom %)	Atomic Weight (grams)	Abundance (wt %)
^{234}U	-	2.446×10^5	0.0054	234.0409	0.0053
^{235}U	4.798 dis/min-μg	7.038×10^8	0.720	235.0439	0.711
^{238}U	0.746 dis/min-μg	4.4683×10^9	99.275	238.0508	99.284
			100.0004		100.0003

where $(\text{wt \%})_i =$

$$\frac{(\text{atom \%})_i \ (\text{atomic weight})_i}{\sum_j (\text{atom \%})_j \ (\text{atomic weight})_j} = \frac{(\text{atom \%})_i \ (\text{atomic weight})_i}{238.02985}$$

Note that the abundance totals 100.0003%. Since it cannot be determined which isotope(s) are in error, the calculations are made with the 0.0003% error unaccounted for.

Specific activity for normal uranium:

$$0.746 \times 0.99284 \times 2 = 1.481 \quad \text{dis/min-μg from } ^{234} \text{ \& } ^{238}U$$
$$4.798 \times 0.00711 = 0.0341 \quad \text{dis/min-μg from } ^{235}U$$
$$1.515 \quad \text{dis/min-μg for normal U}$$

or $(1.515 \text{ dis/min-μg})/(2.22 \text{ dis/min-pCi}) = 0.683 \text{ pCi/μg}$

where ^{234}U is assumed to be in secular equilibrium with the ^{238}U parent.

Note that 2.25% of the total activity is due to ^{235}U and 48.87% each is due to ^{234}U and ^{238}U.

APPENDIX 6

PERTINENT RADIOLOGICAL REGULATIONS, STANDARDS, AND GUIDELINES

Excerpts From

I. DRAFT AMERICAN NATIONAL STANDARD

N13.12

Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use

Where potentially contaminated surfaces are not accessible for measurement (as in some pipes, drains, and ductwork), such property shall not be released pursuant to this standard, but shall be made the subject of case-by-case evaluation.

Property shall not be released for uncontrolled use unless measurements show the total and removable contamination levels to be no greater than the values in Table 1 or Table 2. (The values in Table 2 are easier to apply when the contaminants cannot be individually identified.)

Coatings used to cover the contamination shall not be considered a solution to the contamination problem. That is, the monitoring techniques shall be sufficient to determine, and such determination shall be made, that the total amount of contamination present on and under any coating does not exceed the Table 1 or Table 2 values before release.

APPENDIX 6
(Cont'd.)

TABLE 1

SURFACE CONTAMINATION LIMITS*

Contaminants			Limit (Activity) (dis/min-100 cm^2)+	
Group	Description	Nuclides (Note 1)	Removable	Total (Fixed plus Removable)
1	Nuclides for which the nonoccupational MPC$_a$ (Note 2) is 2 x 10^{-13} Ci/m^3 or less or for which the nonoccupational MPC$_w$ (Note 4) is 2 x 10^{-7} Ci/m^3 or less	^{227}Ac $^{241,242m,243}Am$ $^{249,250,251,252}Cf$ $^{243,244,245,246,247,248}Cm$ $^{125,129}I$ ^{237}Np ^{231}Pa ^{210}Pb $^{238,239,240,242,244}Pu$ $^{226,228}Ra$ $^{228,230}Th$	20	Nondetectable (Note 3)
2	Those nuclides not in Group 1 for which the nonoccupational MPC$_a$ (Note 2) is 1 x 10^{-12} Ci/m^3 or less for which the nonoccupational MPC$_w$ (Note 4) is 1 x 10^{-6} Ci/m^3 or less	^{254}Es ^{256}Fm $^{126,131,133}I$ ^{210}Po ^{223}Ra ^{90}Sr ^{232}Th ^{232}U	200	2000 α Nondetectable β,γ (Note 5)
3	Those nuclides not in Group 1 or Group 2		1000	5000

APPENDIX 6
(Cont'd.)

SURFACE CONTAMINATION LIMITS

*The levels may be averaged over one square meter provided the maximum activity in any area of 100 cm^2 is less than three times the limit value. For purposes of averaging with regard to isolated spots of activity, any square meter of surface shall be considered to be contaminated above the limit L, applicable to 100 cm^2, if (1) from measurements of a representative number n of sections it is determined that $1/n \sum_{i}^{n} S_i \geq L$, where S_i is the dis/min-100 cm^2 determined from measurement of section i; or (2) it is determined that the activity of all isolated spots or particles in any area less than 100 cm^2 exceeds 3 L.

+Disintegrations per minute per square decimeter.

NOTES:

(1) Values presented here are obtained from the Code of Federal Regulations, Title 10, Part 20, April 30, 1975. The most limiting of all given MPC values (for example, soluble versus insoluble) are to be used. In the event of the occurrence of mixtures of radionuclides, the fraction contributed by each constituent of its own limit shall be determined and the sum of the fraction shall be less than 1.

(2) Maximum permissible concentration in air applicable to continuous exposure of members of the public as published by or derived from an authoritative source such as the National Committee on Radiation Protection and Measurements (NCRP), the International Commission on Radiological Protection (ICRP), or the Nuclear Regulatory Commission (NRC). From the Code of Federal Regulations, Title 10, Part 20, Appendix B, Table 2, Column 1.

(3) The instrument utilized for this measurement shall be calibrated to measure at least 100 pCi of any Group 1 contaminants uniformly spread over 100 cm^2.

(4) Maximum permissible concentration in water applicable to members of the public.

(5) The instrument utilized for this measurement shall be calibrated to measure at least 1 nCi of any Group 2 beta or gamma contaminants uniformly spread over an area equivalent to the sensitive area of the detector. Direct survey for unconditional release should be performed in areas where the background is $\leq$ 100 counts per minute. When the survey must be performed in a background exceeding 100 counts per minute, it may be necessary to use the indirect survey method to provide the additional sensitivity required.

APPENDIX 6
(Cont'd.)

ALTERNATE SURFACE CONTAMINATION LIMITS

(All Alpha Emitters, except U_{nat} and Th_{nat}, Considered as a Group)*

Contamination Contingencies	Limit (Activity) (dis/min-100 cm^2)+ Removable	Total (Fixed Plus Removable
If the contaminant cannot be identified; or if alpha emitters other than U_{nat} (Note 1) and Th_{nat} are present; or if the beta emitters comprise ^{227}Ac or ^{228}Ra.	20	Nondetectable (Note 2)
If it is known that all alpha emitters are generated from U_{nat} (Note 1) and Th_{nat}; and if beta emitters are present that, while not identified, do not include ^{227}Ac, ^{125}I, ^{226}Ra, and ^{228}Ra.	200	2000 α Nondetectable β,γ (Note 3)
If it is known that alpha emitters are generated only from U_{nat} (Note 1) and Th_{nat} in equilibrium with its decay products; and if the beta emitters, while not identified, do not include ^{227}Ac, ^{125}I, ^{129}I, ^{90}Sr, ^{223}Ra, ^{228}Ra, ^{126}I, ^{131}I and ^{133}I.	1000	5000

APPENDIX 6
(Cont'd.)

ALTERNATE SURFACE CONTAMINATION LIMITS

*The levels may be averaged over one square meter provided the maximum activity in any area of 100 cm^2 is less than three times the limit value. For purposes of averaging with regard to isolated spots of activity, any square meter of surface shall be considered to be contaminated above the limit L, applicable to 100 cm^2, if (1) from measurements of a representative number n of sections it is determined that $1/n \Sigma_n S_i \geqq L$, where S_i is the dis/min-100 cm^2 determined from measurement of section i; or (2) it is determined that the activity of all isolated spots or particles in any area less than 100 cm^2 exceeds 3 L.

+Disintegrations per minute per square decimeter.

NOTES:

(1) U_{nat} and decay products.

(2) The instrument utilized for this measurement shall be calibrated to measure at least 100 pCi of any Group 1 contaminants uniformly spread over 100 cm^2.

(3) The instrument utilized for this measurement shall be calibrated to measure at least 1 nCi of any Group 2 beta or gamma contaminants uniformly spread over an area equivalent to the sensitive area of the detector. Direct survey of unconditional release should be performed in areas where the background is ≦ 100 counts per minute. When the survey must be performed in a background exceeding 100 counts per minute, it may be necessary to use the indirect survey method to provide the additional sensitivity required.

APPENDIX 6
(Cont'd.)

II. GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BY-PRODUCT SOURCE, OR SPECIAL NUCLEAR MATERIAL

(These have been retyped for purposes of this report)

The instructions in this guide, in conjunction with Table 1, specify the radioactivity and radiation exposure rate limits which should be used in accomplishing the decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table 1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control will be considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.

2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table 1 prior to applying the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.

3. The radioactivity on the interior surfaces of pipes, drain lines, or duct work shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or duct work. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.

4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include but would not be limited to, special circumstances such as razing of buildings, transfer of premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such request must:

   a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

APPENDIX 6
(Cont'd.)

b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table 1. A copy of the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also the Director of the Regional Office of the Office of Inspection and Enforcement, USNRC, having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

a. Identify the premises.

b. Show that reasonable effort has been made to eliminate residual contamination.

c. Describe the scope of the survey and general procedures followed.

d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

APPENDIX 6
(Cont'd.)

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LIMITS

NUCLIDES[a]	AVERAGE[bcf]	MAXIMUM[bdf]	REMOVABLE[bef]
U-nat, ^{235}U, ^{238}U and associated decay products	5000 dis/min-100 cm^2 α	15,000 dis/min-100 cm^2 α	1000 dis/min-100 cm^2 α
Transuranics, ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa, ^{227}Ac, ^{125}I, ^{129}I	100 dis/min-100 cm^2	300 dis/min-100 cm^2	20 dis/min-100 cm^2
Th-nat, ^{232}Th ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{131}I, ^{133}I	1000 dis/min-100 cm^2	3,000 dis/min-100 cm^2	200 dis/min-100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others	5000 dis/min-100 cm^2 $\beta\gamma$	15,000 dis/min-100 cm^2 $\beta\gamma$	1000 dis/min-100 cm^2 $\beta\gamma$

APPENDIX 6
(Cont'd.)

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

[a]Where surface contamination by both alpha and beta-gamma emitting nuclides exists, the limits established for alpha and beta-gamma emitting nuclides should apply independently.

[b]As used in this table, dis/min (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c]Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d]The maximum contamination level applies to an area of not more than 100 cm^2.

[e]The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

APPENDIX 6
(Cont'd.)

III. SURGEON GENERAL'S GUIDELINES
as included in 10 CFR Part 712
Grand Junction Remedial Action Criteria

712.1 Purpose

(a) determination by DOE of the need for, priority of and selection of appropriate remedial action to limit the exposure of individuals in the area of Grand Junction, Colorado, to radiation emanating from uranium mill tailings which have been used as construction-related material.

(b) The regulations in this part are issued pursuant to Pub. L. 92-314 (86 Stat. 222) of June 16, 1972.

712.2 Scope

The regulations in this part apply to all structures in the area of Grand Junction, Colorado, under or adjacent to which uranium mill tailings have been used as a construction-related material between January 1, 1951, and June 16, 1972, inclusive.

712.3 Definitions

As used in this part:

(a) "Administrator" means the Administrator of Energy Research and Development or his duly authorized representative.

(b) "Area of Grand Junction, Colorado," means Mesa County, Colorado

(c) "Background" means radiation arising from cosmic rays and radioactive material other than uranium mill tailings.

(d) "DOE" means the U.S. Department of Energy or any duly authorized representative thereof.

(e) "Construction-related material" means any material used in the construction of a structure.

(f) "External gamma radiation level" means the average gamma radiation exposure rate for the habitable area of a structure as measured near floor level.

APPENDIX 6
(Cont'd.)

(g) "Indoor radon daughter concentration level" means that concentration of radon daughters determined by: (1) averaging the results of six air samples each of at least 100 hours duration, and taken at a minimum of 4-week intervals throughout the year in a habitable area of a structure, or (2) utilizing some other procedure approved by the Commission.

(h) "Milliroentgen" (mR) means a unit equal to one-thousandth (1/1000) of a roentgen which roentgen is defined as an exposure dose of X or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign.

(i) "Radiation" means the electromagnetic energy (gamma) and the particulate radiation (alpha and beta) which emanate from the radioactive decay of radium and its daughter products.

(j) "Radon daughters" means the consecutive decay products of radon-222. Generally, these include Radium A (polonium-218), Radium B (lead-214), Radium C (bismuth-214), and Radium C' (polonium-214).

(k) "Remedial action" means any action taken with a reasonable expectation of reducing the radiation exposure resulting from uranium mill tailings which have been used as construction-related material in and around structures in the area of Grand Junction, Colorado.

(l) "Surgeon General's Guidelines" means radiation guidelines related to uranium mill tailings prepared and released by the Office of the U.S. Surgeon General, Department of Health, Education and Welfare on July 27, 1970.

(m) "Uranium mill tailings" means tailings from a uranium milling operation involved in the Federal uranium procurement program.

(n) "Working Level" (WL) means any combination of short-lived radon daughter products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

712.4 Interpretations

Except as specifically authorized by the Administrator in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of DOE other than a written interpretation by the General Counsel will be recognized to be binding upon DOE.

712.5 Communications

Except where otherwise specified in this part, all communications concerning the regulations in this part should be addressed to the Director, Division of Safety, Standards, and Compliance, U.S. Department of Energy, Washington, D.C. 20545.

APPENDIX 6
(Cont'd.)

712.6 General radiation exposure level criteria for remedial action.

The basis for undertaking remedial action shall be the applicable guidelines published by the Surgeon General of the United States. These guidelines recommended the following graded action levels for remedial action in terms of external gamma radiation level (EGR) and indoor radon daughter concentration level (RDC) above background found within dwellings constructed on or with uranium mill tailings.

EGR	RDC	Recommendation
Greater than 0.1 mR/h	Greater than 0.05 WL	Remedial action indicated.
From 0.05 to 0.1 mR/h	From 0.01 to 0.05 WL	Remedial action may be suggested.
Less than 0.05 mR/h	Less than 0.01 WL	No remedial action indicated

712.7 Criteria for determination of possible need for remedial action

Once it is determined that a possible need for remedial action exists the record owner of a structure shall be notified of that structure's eligibility for an engineering assessment to confirm the need for remedial action and to ascertain the most appropriate remedial measure, if any. A determination of possible need will be made if as a result of the presence of uranium mill tailings under or adjacent to the structure, one of the following criteria is met

(a) Where DOE approved data on indoor radon daughter concentration levels are available

(1) For dwellings and schoolrooms: An indoor radon daughter concentration level of 0.01 WL or greater above background.

(2) For other structures: An indoor radon daughter concentration level of 0.03 WL or greater above background.

(b) Where DOE approved data on indoor radon daughter concentration levels are not available:

(1) For dwellings and schoolrooms:

(i) An external gamma radiation level of 0.05 mR/h or greater above background.

APPENDIX 6
(Cont'd.)

(ii) An indoor radon daughter concentration level of 0.01 WL or greater above background (presumed).

(A) It may be presumed that if the external gamma radiation level is equal to or exceed 0.02 mR/h above background, the indoor radon daughter concentration level equals or exceeds 0.01 WL above background.

(B) It should be presumed that if the external gamma radiation level is less than 0.001 mR/h above background, the indoor radon daughter concentration level is less than 0.01 WL above background, and no possible need for remedial actions exists.

(C) If the external gamma radiation level is equal to or greater than 0.001 mR/h above background but is less than 0.02 mR/h above background, measurements will be required to ascertain the indoor radon daughter concentration level.

(2) For other structures:

(i) An external gamma radiation level of 0.15 mR/h above background averaged on a room-by-room basis.

(ii) No presumptions shall be made on the external gamma radiation level/indoor radon daughter concentration level relationship. Decisions will be made in individual cases based upon the results of actual measurements.

712.8 Determination of possible need for remedial action where criteria have not been met.

The possible need for remedial action may be determined where the criteria in 712.7 have not been met if various other factors are present. Such factors include, but are not necessarily limited to, size of the affected area, distribution of radiation levels in the affected area, amount of tailings, age of individuals occupying affected area, occupancy time, and use of the affected area.

712.9 Factors to be considered in determination of order of priority for remedial action.

In determining the order or priority for execution of remedial action, consideration shall be given, but not necessarily limited to, the following factors:

(a) Classification of structure. Dwellings and schools shall be considered first.

(b) Availability of data. Those structures for which data on indoor radon daughter concentration levels and/or external gamma radiation levels are available when the program starts and which meet the criteria in 712.7 will be considered first.

APPENDIX 6
(Cont'd.)

(g) Climatic conditions. Climatic conditions or other seasonable considerations may affect the scheduling of certain remedial measures.

712.10 Selection of appropriate remedial action.

(a) Tailings will be removed from those structures where the appropriately averaged external gamma radiation level is equal to or greater than 0.05 mR/h above background in the case of dwellings and schools and 0.15 mR/h above background in the case of other structures.

(b) Where the criterion in paragraph (a) of this section is not met, other remedial action techniques, including but not limited to sealants, ventilation, and shielding may be considered in addition to that of tailings removal. DOE shall select the remedial action technique or combination of techniques, which it determines to be the most appropriate under the circumstances.

IV. EXCERPTS FROM DOE 5480.1 Chg. 6, Chapter XI

"Requirements for Radiation Protection"

Exposure of Individuals and Population Groups in Uncontrolled Areas. Exposures to members of the public shall be as low as reasonably achievable levels within the standards prescribed below.

Radiation Protection Standards
for Internal and External Exposure
of Members of the Public

	Annual Dose Equivalent or Dose Commitment	
Type of Exposure	Based on Dose to Individuals at Points of Maximum Probable Exposure	Based on Average Dose to a Suitable Sample of the Exposed Population
Whole body, gonads, or bone marrow	0.5 rem (or 500 mrem)	0.17 rem (or 170 mrem)
Other organs	1.5 rem (or 1500 mrem)	0.5 rem (or 500 mrem)

APPENDIX 6
(cont'd.)

V. 40 CFCFR 192 - HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM MILL TAILINGS

Authority: Section 275 of the Atomic Energy Act of 1954, 42 U.S.C. 2022, as added by the Uranium Mill Tailings Radiation Control Act of 1978, PL 95-604.

Subpart B -- Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

192.10 Applicability

This subpart applies to land and buildings that are part of any processing site designated by the Secretary of Energy under Section 102 of the Act. Section 101 of the Act, states, in part, that "processing site" means -

(a) any site, including the mill, containing residual radioactive materials at which all or substantially all of the uranium was produced for sale to any Federal agency prior to January 1, 1971, under a contract with any Federal agency, except in the case of a site at or near Slick Rock, Colorado, unless --

(1) such site was owned or controlled as of January 1, 1978, or is thereafter owned or controled, by any Federal agency, or

(2) a license (issued by the {Nuclear Regulatory} Commission or its predecessor agency under the Atomic Energy Act of 1954 or by a State as permitted under Section 274 of such Act) for the production at site of any uranium or thorium product dervied from ores is in effect on January 1, 1978, or is issued or renewed after such date; and

(b) any other real property or improvement thereon which --

(1) is in the vicinity of such site, and

(2) is determined by the Secretary, in consultation with the Commission, to be contaminated with residual radioactive materials dervied from such site.

192.11 Definitions

(a) Unless otherwise indicated in this subpart, all terms shall have the same meaning as defined in Title I of the Act or in Subpart A.

(b) Land means any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building.

(c) Working Level (WL) means any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of alpha particles with a total energy of 130 billion electron volts.

APPENDIX 6
(cont'd.)

(d) Soil means all unconsolidated materials normally found on or near the surface of the earth including, but not limited to, silts, clays, sands, gravel, and small rocks.

192.12 Standards

Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site:

(a) the concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than --

(1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and

(2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.

(b) in any occupied or habitable building --

(1) the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, and

(2) the level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.

APPENDIX 7

ESTIMATED EXTENT OF CONTAMINATION

Estimates of the extent of the contamination at the assessed site are based on the total volume, mass, and quantity of radioactive material in the contaminated area. The volume is the product of the surface area and the depth of the contamination. The mass is the product of the volume and the density of the material. A density of 1.5 g/cm^3 is sued for soil. The concentration (pDi/g) of the specific radioisotope is determined by radiochemical analysis of the soil. The total quantity of radioactive material is the product of the concentration of the specific radioisotope and the total mass of material.

Often there is more than one contaminant in the soil (or contaminated material) and the contaminants are not uniformly distributed throughout the material. In these cases, it is necessary to estimate the fraction of the material containing each contaminant in order to assess the total quantity of the radioactive material. This estimate of the fraction of the material containing each contaminant is based on the radiochemical analysis of randomly selected samples.

Estimates of the extent of contamination are usually determined for averaged (Option 1) and maximum or worst-case (Option 2) conditions. Sample calculations for the extent of contamination in the "Back Forty" area of the Albany, Oregon Bureau of Mines Site are as follows:

Volume (Average) = 34,800 ft^2 (area) x 3.6 ft (avg. depth) = 125,000 ft^3
= 3,550 m^3

Volume (Maximum) = 34,800 ft^2 (area) x 9 ft (max. depth) = 314,000 ft^3
= 8,880 m^3

Mass (Average) = 3,550 m^3 x 1,500 kg/m^3 = 5.33 x 10^6 kg
Mass (Maximum) = 8,880 m^3 x 1,500 kg/m^3 = 1.33 x 10^7 kg

Estimated Total Activity for ^{226}Ra (chain)

Average: 5.33 x 10^6 kg x 14 x 10^{-12} Ci/g x 10^{-3} g/kg x .05 (fraction)* = 0.004 Ci

Maximum: 1.33 x 10^7 kg x 16 x 10^{-12} Ci/g x 10^{-3} g/kg x .05 (fraction)* = 0.011 Ci

*This represents the estimate of the fraction of the total mass contaminated with the ^{226}Ra chain.

APPENDIX 8

EVALUATION OF RADIATION EXPOSURES

INTRODUCTION

A. Types of Radiation

Radiation is the emission or transmission of energy in the form of waves or particles. Examples are acoustic waves (i.e., sound), electromagnetic waves (such as radio, light, x- and gamma-rays), and particulate radiations (such as alpha particles, beta particles, neutrons, protons, and other elementary particles).

The class of radiation of importance to this report is known as ionizing radiation. Ionizing radiations are those, either electromagnetic or particulate, with sufficient energy to ionize matter, i.e., to remove or displace electrons from atoms and molecules. The most common types of ionizing radiation are x- and gamma-rays, alpha particles, beta particles, and neutrons.

X- and gamma-rays are electromagnetic waves of pure energy, having no charge and no mass or existence at rest. Gamma-rays and x-rays are identical except that x-rays originate in the atom and gamma-rays originate in the nucleus of an atom. X- and gamma-rays are highly penetrating and can pass through relatively thick materials before interacting. Upon interaction, some or all of the energy is transferred to electrons which, in turn, produce additional ionizations while coming to rest.

Alpha particles are positively charged particulates composed of two neutrons and two protons, identical to the nucleus of a helium atom. Due to its comparatively large mass and double charge, an alpha particle interacts readily with matter and penetrates only a very short distance before coming to rest, causing intense ionization along its path.

Beta particles are negatively charged free electrons moving at high speeds. Due to its comparatively small mass and single charge, a beta particle's penetration through matter is intermediate between that of the alpha particle and the gamma-ray, causing fewer ionizations per unit path length than an alpha particle.

B. Sources of Radiation

Ionizing radiations arise from terrestrial radioactive materials (both naturally occurring and man-made), extra-terrestrial (cosmic) sources, and radiation-producing machines. The sources of ionizing radiation important to this report are radioactive materials and cosmic sources.

Most atoms of the elements in our environment remain structurally stable. With time, an atom of potassium, for instance, may change its association with other atoms in chemical reactions and become part of other compounds, but it will always remain a potassium atom. Radioactive atoms, on the other hand, are

APPENDIX 8
(cont'd.)

not stable and will spontaneously emit radiation in order to achieve a more stable state. Because of this spontaneous transformation, the ratio of protons and neutrons in the nucleus of an atom is altered toward a more stable condition. Radiation may be emitted from the nucleus as alpha particles, beta particles, neutrons, or gamma-rays, depending uniquely upon each particular radionuclide. Radionuclides decay at characteristic rates dependent upon the degree of stability and characterized by a period of time called the half-life. In one half-life, the number of radioactive atoms and, therefore, the amount of radiation emitted, decrease by one half.

The exposure of man to terrestrial radiation is due to naturally occuring radionuclides and also to "man-made" or technologically enhanced radioactive materials. Several dozen radionuclides occur naturally, some having half-lives of at least the same order of magnitude as the estimated age of the earth. The majority of these naturally occurring radionuclides are isotopes of the heavy elements and belong to three distinct radioactive series headed by uranium-238, uranium-235, and thorium-232. Each of these decays to stable isotopes of lead (Pb) through a sequence of radionuclides of widely varying half-lives. Other naturally occurring radionuclides, which decay directly to a stable nuclide, are potassium-40 and rubidium-87. It should be noted that even though the isotopic abundance of potassium-40 is less than 0.012%, potassium is so widespread that potassium-40 contributes about one-third of the radiation dose received by man from natural background radiation. A major portion of the exposure (dose) of man from external terrestrial radiation is due to the radionuclides in the soil, primarily potassium-40 and the radioactive decay-chain products of thorium-232 and uranium-238. The naturally occurring radionuclides deposited internally in man through uptake by inhalation/ingestion of air, food, and drinking water containing the natural radioactive material also contribute significantly to his total dose. Many other radionuclides are referred to as "man made" in the sense that they can be produced in large quantities by such means as nuclear reactors, accelerators, or nuclear weapons tests.

The term "cosmic radiation" refers both to the primary energetic particles of extra-terrestrial origin that are incident on the earth's atmosphere and to the secondary particles that are generated by the interaction of these primary particles with the atmosphere, and reach ground level. Primary cosmic radiation consists of "galactic" particles externally incident on the solar system, and "solar" particles emitted by the sun. This radiation is composed primarily of energetic protons and alpha particles. The first generation of secondary particles (secondary cosmic radiation), produced by nuclear interactions of the primary particles with the atmosphere, consists predominantly of neutrons, protons, and pions. Pion decay, in turn, results in the production of electrons, photons, and muons. At the lower elevations, the highly penetrating muons and their associated decay and collision electrons are the dominant components of the cosmic-ray particle flux density. These particles, together with photons from the gamma-emitting, naturally occurring radionuclides in the local environment, form the external penetrating component of the background environmental radiation field which provides a significant portion of the whole-body radiation dose to man.

APPENDIX 8
(cont'd.)

In addition to the direct cosmic radiation, cosmic sources include cosmic-ray-produced radioactivity, i.e., cosmogenic radionuclides. The major production of cosmogenic radionuclides is through interaction of the cosmic rays with the atmospheric gases through a variety of spallation or neutron-capture reactions. The four cosmogenic radionuclides that contribute a measurable radiation dose to man are carbon-14, sodium-22, beryllium-7, and tritium (hydrogen-3), all produced in the atmosphere.

BACKGROUND RADIATION DOSES

Background radiation doses are comprised of an external component of radiation impinging on man from outside the body and an internal component due to radioactive materials taken into the body by inhalation or ingestion.

Radiation dose may be expressed in units of rads or rems, depending upon whether the reference is to the energy deposited or to the biological effect. A rad is the amount of radiation that deposits a certain amount of energy in each gram of material. It applies to all radiations and to all materials which absorb that radiation.

Since different types of radiation produce ionizations at different rates as they pass through tissue, differences in damage to tissues (and hence the biological effectiveness of different radiations) has been noticed. A rem is defined as the amount of energy absorbed (in rads) from a given type of radiation multiplied by the factor appropriate for the particular type of radiation in order to approximate the biological damage that it causes relative to a rad of x or gamma radiation. The concept behind the unit "rem" permits evaluation of potential effects from radiation exposure without regard to the type of radiation or its source. One rem received from cosmic radiation results in the same biological effects as one rem from medical x-rays or one rem from the radiations emitted by naturally occurring or man-made radioactive materials.

The external penetrating radiation dose to man derives from both terrestrial radioactivity and cosmic radiation. The terrestrial component is due primarily to the gamma dose from potassium-40 and the radioactive decay products of thorium-232 and uranium-238 in soil as well as from the beta-gamma dose from radon daughters in the atmosphere. Radon is a gaseous member of the uranium-238 chain. The population-weighted external dose to an individual's whole body from terrestrial sources in the United States has been estimated as 15 mrem per year for the Atlantic and Gulf Coastal Plain, 57 mrem per year for an indeterminate area along the Rocky Mountains, and 29 mrem per year for the majority of the rest of the United States. The overall population-weighted external dose for the U.S. population as a whole has been estimated to be 26 mrem per year.

The cosmic radiation dose, due to the charged particles and neutrons from secondary cosmic rays, is typically about 30% to 50% of the total from all external environmental radiation. The cosmic-ray dose to the population is estimated to be 26 mrem per year for those living at sea level, and increases with increasing altitude. Considering the altitude distribution of the U.S.

APPENDIX 8
(cont'd.)

population, the population-weighted external cosmic-ray dose is 28 mrem per year. The population-weighted total external dose from terrestrial plus cosmic sources is thus 54 mrem per year for the U.S. population as a whole.

The internal radiation doses derive from terrestrial and cosmogenic radionuclides deposited within the body through uptake by inhalation/ingestion of air, food, and drinking water. Once deposited in the body, many radioactive materials can be incorporated into tissues because the chemical properties of the radioisotopes are identical or similar to stable isotopes in the tissues. Potassium-40, for instance, is incorporated into tissues in the same manner as stable potassium atoms because the chemical properties are identical; radioactive radium and strontium can be incorporated into tissues in the same manner as calcium because their chemical properties are similar. Once deposited in tissue, these radionuclides emit radiation that results in the internal dose to individual organs and/or the whole body as long as it is in the body.

The internal dose to the lung is due primarily to the inhalation of polonium-218 and -214 (radon daughters), lead-212 and bismuth-212 (thoron daughters) and polonium-210 (one of the longer-lived radon decay products). The dose to the lung is about 100 mrem per year from inhaled natural radioactivity. The internal dose from subsequent incorporation of inhaled or ingested radioactivity is due to a beta-gamma dose from incorporation of potassium-40, rubidium-87, and cosmogenic nuclides, and an alpha dose from incorporation of primarily polonium-210, radium-226 and -228, and uranium-238 and -234. The dose to man from internally incorporated radionuclides is about 28 mrem per year to the gonads, about 25 mrem per year to the bone marrow, lung, and other soft tissues, and about 117 mrem per year to the bone (osteocytes). The bone dose arises primarily from the alpha-emitting members of the naturally occurring series, with polonium-210 being the largest contributor. The gonadal and soft tissue doses arise primarily from the beta and gamma emissions from potassium-40. The total internal dose from inhaled plus incorporated radioactivity is about 28 mrem per year to the gonads (or whole-body dose), about 125 mrem per year to the lung, about 25 mrem per year to the bone marrow, and about 117 mrem per year to the bone (osteocytes).

The total natural background radiation dose is the sum of the external and internal components. The population-weighted dose for the U.S. population as a whole is about 82 mrem per year to the gonads or whole body, about 179 mrem per year to the lung, about 79 mrem per year to the bone marrow, and about 171 mrem per year to the bone (osteocytes).

Besides the natural background radiation, background radiation doses include contributions from man-made or technologically enhanced sources of radiation. By far, the most significant are x-ray and radiopharmaceutical medical examinations. These contribute a population-averaged dose estimated to be 70 mrem per year for the U.S. population as a whole. Fallout from nuclear weapons testing through 1970 has contributed 50-year dose commitments estimated as 80 mrem external, and 30, 20, and 45 mrem internal to the gonads, lung, and bone marrow, respectively. Contributions from the use of fossil fuels (natural gas and coal) and nuclear reactors; mining, milling, and tailings piles; television sets,

APPENDIX 8
(cont'd.)

smoke detectors, and watch dials could be responsible for an additional 5 mrem per year, averaged over the U.S. population as a whole. In addition, the use of radiation or radioactivity for scientific, industrial, or medical purposes may cause workers in the industry and, to a lesser extent, members of the general public, to receive some radiation exposure above natural background.

EVALUATION OF RADIATION DOSE AND POTENTIAL HAZARD

Radiation, regardless of its sources, is considered to be a hazard because of its potential for producing adverse effects on human life. Very large amounts of radiation received over a brief period, i.e., hundreds of rem delivered within a few hours, can produce severe injury or death within days or weeks. Distributed over longer intervals, however, these same doses would not cause early illness or fatality. At doses and rates too low to produce these immediate symptoms, chronic or repeated exposure to radiation can bring about biological damage which does not appear until years or decades later. These low-level effects are stochastic in nature; their probability rather than their severity increases with dose. Primary among these latent or delayed effects are somatic effects, where insults such as cancers occur directly to the individual exposed, and genetic defects, where, through damage to the reproductive cells of the exposed individual, disability and disease ranging from subtle to severe are transmitted to his offspring.

Clinical or observed evidence of a relationship between radiation and human cancers arise from several sources. The most important data come from the victims of Hiroshima and Nagasaki, patients exposed during medical therapy, radium dial painters, and uranium miners. Data exist only for relatively large doses; there have been no direct measurements of increased incidence of cancer for low-level radiation exposures. Evaluation of the available data has lead to estimates of the risk of radiation-induced cancer; estimated risks for the lower doses have been derived by linear extrapolation from the higher doses. All radiation exposures then, no matter how small, are assumed to be capable of increasing an individual's risk of contracting cancer.

Data on genetic defects resulting from radiation exposure of humans is not available to the extent necessary to allow an estimate of the risk of radiation-induced effects. Data from animals, along with general knowledge of genetics, have been used to derive an estimate of the risks of genetic effects.

Estimates of health effects from radiation doses are usually based on risk factors as provided in International Commission on Radiological Protection (ICRP), National Research Council Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR), or United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reports. Multiplying the estimated dose by the appropriate risk factor provides an estimate of the risk or probability of induction of health effects to an individual or his descendants as a result of that exposure. The evaluation of these risk factors is presently subject to large uncertainties and, therefore, potential continual revision. The risk

APPENDIX 8
(cont'd.)

factors recommended by the ICRP for cancer mortality and hereditary ill health to the first and second generations are 10^{-4} per rem of whole body dose and 4×10^{-5} per rem of gonadal dose, respectively. As an example, a whole-body dose of 1 rem would be estimated to add a risk of cancer mortality to the exposed invididual of 10^{-4}, i.e., 1 chance in 10,000. However, a precise numerical value cannot be assigned with any certainty to a particular individual's increase in risk attributable to radiation exposure. The reasons for this are numerous and include the following: (1) uncertainties over the influence of the individual's age, state of health, personal habits, family medical history, and previous or concurrent exposure to other cancer-causing agents, (2) the variability in the latent period (time between exposure and physical evidence of disease), and (3) the uncertainty in the risk factor itself.

To be meaningful, an attempt should be made to view such risk estimates in the appropriate context. One useful comparison is with risks encountered in normal life. Another comparison, potentially more useful, is with an estimation of the risks attributable to natural background radiation. Radiation from natural external and internal radioactivity results in the same types of interactions with body tissues as that from "man-made" radioactivity. Hence, the risks from a specified dose are the same regardless of the source. Rather than going through an intermediate step involving risk factors, doses can also be compared directly to natural background radiation doses.

Besides estimation of risks and comparisons to natural background, doses may be compared to standards and regulations. The appropriate standards, the Department of Energy's "Requirements for Radiation Protection," give limits for external and internal exposures for the whole body and specified organs which are expressed as the permissible dose or dose commitment annually in addition to natural background and medical exposures. There are, in general, two sets of limits, one applicable to occupationally exposed persons and the second applicable to individuals and population groups of the general public. The limits for individuals of the public are one-tenth of those permitted for occupationally exposed individuals. The set of limits important to this report are those applicable to individuals and population groups of the public. The limits for individuals of the public are 500 mrem per year to the whole body, gonads, or bone marrow and 1500 mrem per year to other organs. The limits for population groups of the public are 170 mrem to the whole body, gonads, or bone marrow and 500 mrem per year to other organs, averaged over the group. In either case, exposures are to be limited to the lowest levels reasonably achievable within the given limits.

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